# PEACE RIVER OILS #1 STUDY

# ENVIRONMENTAL ASSESSMENT

Alberta
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Alberta Environment

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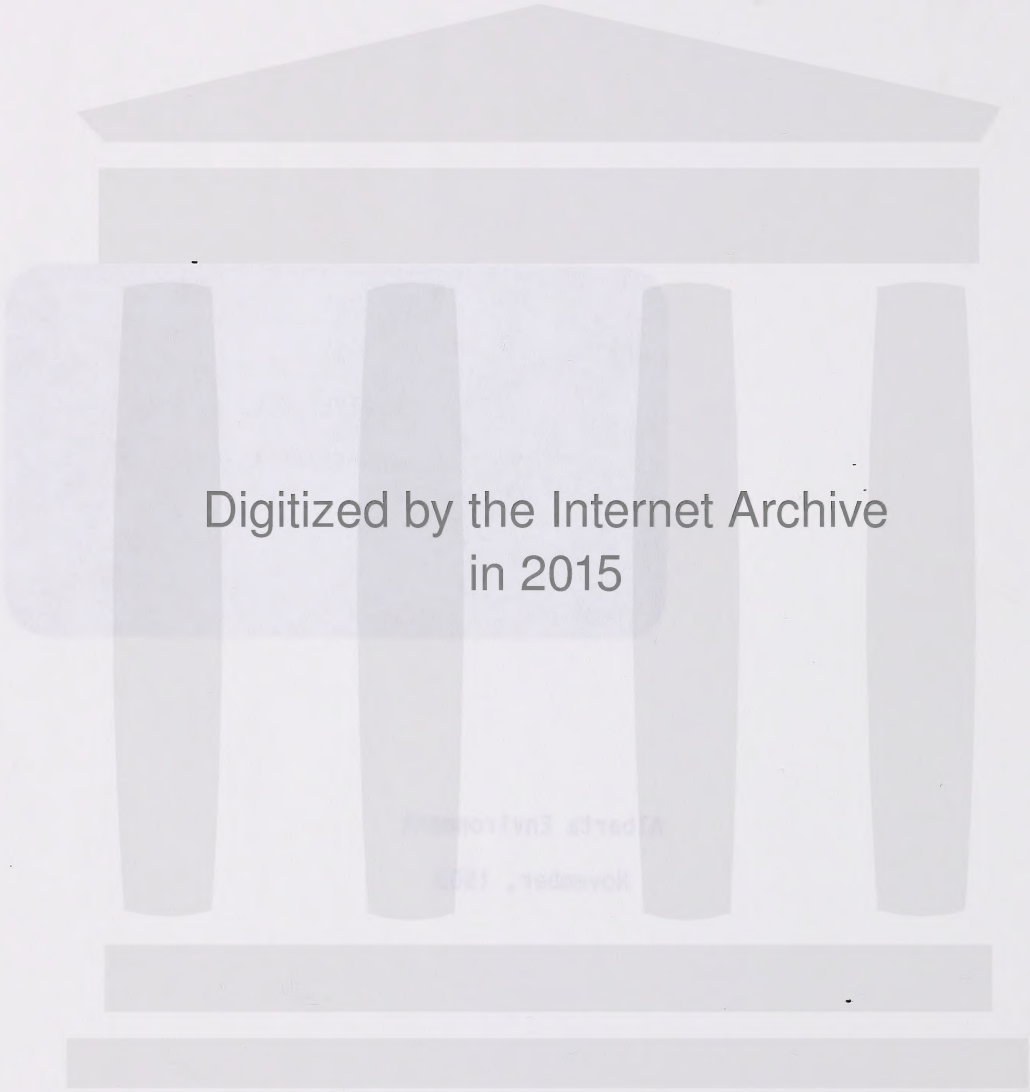

## EXECUTIVE SUMMARY

The Environmental Assessment Division of Alberta Environment coordinated an investigation of the impacts which have occurred as a result of continuous water and gas discharges from the abandoned Peace River Oils #1 Well (LSD 4-31-85-20-W5M).

The Peace River Oils #1 Well, the old domestic well on the Nixon property, and the Peace River in the vicinity of the oil well were sampled on several occasions in 1988 and 1989 in order to assess a) the quality of the water flowing from the oil well, b) the quality of Nixon's old domestic well water compared to that of water from the oil well, and c) the effects of the oil well water discharge on the Peace River.

Gaseous hydrogen sulphide emissions in the vicinity of the well were monitored by the ERCB. The land surface adjoining the well was surveyed to assess a) the effects of the well on nearby soils and vegetation, and b) the origin of the alleged "sinkholes".

Chemical analyses carried out on the water samples included routine inorganic chemistry, volatile and semi-volatile priority pollutants, and hydrocarbons. Hydrocarbons were quantified, fingerprinted, and compared among samples. Microtox tests were conducted to assess the toxicity of the water samples. Benthic invertebrate community structure was used to assess whether the oil well discharge affects the aquatic biota in the Peace River. Electromagnetic surveys and soil analyses were carried out to assess soil and subsoil conditions.

Discharged Water

The water which flows out of the Peace River Oils #1 Well contained high concentrations of sodium, chloride, and total dissolved solids (TDS). These concentrations were similar to those of seawater. The well water also had moderate to high concentrations of barium, boron, lithium, strontium, ammonia, hydrogen sulphide, and hydrocarbons. Hydrocarbons and related compounds included weathered crude oil, chloroform, benzene, phenol, other phenolic compounds, and polycyclic aromatic hydrocarbons. The concentrations of several of these organic and inorganic constituents exceeded CCREM (1987) guidelines for irrigation of agricultural land and for the protection of aquatic life. Microtox tests indicated that the Peace River Oils #1 Well water was extremely toxic.

Discharged Gas

Within a 60 m radius of the well, hourly average hydrogen sulphide concentrations ranged from 0.023 to 0.223 ppm and were well in excess of air quality guidelines (Clean Air Act - Maximum Levels - Regulation) which specify maximum hourly average concentrations of 0.01 ppm. Some peak concentrations were beyond the scale of the analyzer in use (i.e. > 0.50 ppm). Hourly average hydrogen sulphide concentrations at a location 300 m east of the well were 0.004 ppm with peak concentrations of 0.005 ppm, and met air quality guidelines.

Domestic Well Water Quality

Sampling of the Nixon's domestic well water was made difficult by the presence of debris in the casing. Although the well is reported to

be 20 m deep, samples could only be collected at a depth of 4 to 7 m. The chemical analyses of the samples reflect the quality of the water in the well, but not necessarily that of the geological formation in which the well is completed. To get a more representative sample, the well would have to be cleaned out and purged to remove stagnant water.

Results of routine water analyses indicate that the well water is of the sodium bicarbonate type, which is often associated with bedrock aquifers. Water well records of the area reveal similar water from wells completed in the river valley both upstream (SW2-85-21-W5) and downstream (SW16-86-20-W5) of the Nixon farm. Water from wells to the southeast, outside of the river valley, is of the calcium magnesium sulphate type, commonly associated with drift aquifers. The chloride level in Nixon's old domestic well is, with 156 mg/L (drinking water guideline 250 mg/L), the highest of the 11 wells surveyed. Next highest, with 65 mg/L, is a well 5 km downstream, also in the valley. Phenols were also identified in the well water.

The analyses of hydrocarbons revealed the presence of heavy hydrocarbons which matched those from the Peace River Oils #1 Well. The Microtox test indicated that the water collected in the old domestic well was extremely toxic.

The high chloride levels, the presence of phenols, the similarity between hydrocarbons found in the domestic and in the oil well and the Microtox test results suggest that the domestic well at Nixon's farm was contaminated.

Peace River Water Quality

The dilution of the Peace River Oils #1 Well effluent in the Peace River was so great (1:10,000 at low flows) that no effects other than a slight increase in chloride concentration could be detected in the water quality of the Peace River at a monitoring site located approximately 30 km downstream of the well. Other factors such as the effect of tributaries and the possible inflow from natural gas wells in the area complicated the assessment.

Closer to the well, conductivity was used to trace the effluent in the Peace River. The well effluent appeared to sink to the bottom upon its entry in the river, then mixed vertically within 1 km. Lateral mixing was very slow: at high flows in August 1989, the plume was still discernible 13 km downstream of the well outfall. The plume appeared to extend further towards the centre of the river at low flow (May 1989) than at high flow (August 1989), at a given site. Concentrations and composition of hydrocarbons were similar immediately upstream and immediately downstream of the well. None of the Peace River samples collected for Microtox testing was toxic.

Variations in the composition of the benthic invertebrate community in the 30 km downstream of the oil well were related to variations in substrate characteristics rather than to the effects of the oil well. However, invertebrates collected within 100 m downstream of the well were considerably less diverse and somewhat less abundant than invertebrates collected 100 m upstream of the well. This implies that the well outflow has some local adverse effects on river biota.

Effects on Crops and Soils

Crops on land immediately to the north and to the south of the lease area and crops on land within the lease area exhibited poor growth or no growth at all. This condition was associated with sour smelling gas in the topsoil and subsoil, high chloride levels in the topsoil, high SAR (sodium adsorption ratio) and EC (electric conductance) and poor soil texture. Crop growth further to the south and east of the lease area was used as a control and rated as poor to excellent.

Alleged saltwater contamination of soil and groundwater and the development of "sinkholes" were investigated in the vicinity of the Peace River Oils No. 1 Well in July, 1989. Note that the water in "sinkholes" was not sampled because the depressions had been plowed over and seeded to wheat, as in the rest of the field. An electromagnetic (EM) survey was run around the oil well to include a line along the Peace River, and a traverse across a flood-plain and along a flood water channel at the base of the east valley slope where a blow-out cavity was located. Measurements were made at 3 and 6 m depth. This survey also included a line that traversed a collapse feature, thought to be a "sinkhole".

Oil and saltwater seepage has long been observed in the Peace River valley. Natural contamination is therefore expected in valley soils and groundwater in variable quantities.

STUDY PERSONNEL

B. Jackson and J. Willis collected the samples from the Peace River, the Peace River Oils #1 Well and some of the samples from Nixon's old domestic well. M. de Brentani collected samples from Nixon's old domestic well for routine water analyses and carried the electromagnetic survey out with the assistance of E. Lorberg. A. Jans collected soil samples and carried the on-site soil and crop inspection.

Water quality samples were analyzed at the Alberta Environmental Centre (AEC) under the supervision of F. Dieken and D. Smillie.

Microtox samples were processed at the AEC under the supervision of A.A. Qureshi.

Benthic invertebrate samples were processed by W.J. Anderson with the assistance of M. Mychajluk and R. Casey.

Data were analyzed and the report prepared by A.M. Anderson, M. de Brentani, A. Jans, and E. Lorberg, with the assistance of L. Noton and D. Trew.

The report was typed by L. Lockhart and the figures were drafted under the supervision of T. Zenith (Design and Construction Division).

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## 1.0 INTRODUCTION

This report summarizes the results of investigations carried out by the Environmental Protection Services at the site of a long-term, continuously flowing, and abandoned oil well on the valley floor of the Peace River. The following information was extracted from memoranda from Morin (1989) and from Ozoray (1989), and provides historical background to this issue.

The Peace River Oils #1 Well (LSD 4-31-85-20-W5M) was drilled in 1916 in an attempt to locate hydrocarbons in the Peace River Formation. Most of the wells drilled in the earlier part of the century were abandoned in the mid-1950's. The ERCB made two costly, but unsuccessful attempts to abandon the Peace River Oils #1 Well. During one of these attempts salt water from the well spilled over adjoining crop land.

The well is located on the right bank of the Peace River about 20 km downstream of Peace River. It is discharging 30 to 50 l/s of salt water into the Peace River. Natural gas, containing 1% hydrogen sulphide, escapes in sufficient amounts to support a continuous flame at the well head. The salt water which is under pressure experiences a pressure gradient towards the river and may enter the river in other places than the well site. Salt water has been observed to enter the river in a backwater one quarter mile away from the well site. Salt water can also enter the Quaternary deposits which are a major aquifer in the area.

The investigation of environmental effects of the flowing well was initiated in response to a request from the ERCB who has in turn responded to complaints from the current landowner.

The purpose of this investigation was to:

1. assess the quality of Peace River Oils #1 Well outflow and to monitor the hydrogen sulphide emissions;
2. assess the impact of this water on the Peace River;
3. compare the quality of Nixon's old domestic well water with that of the oil well effluent;
4. assess the effects of the well on nearby soils and vegetation, and
5. assess the origin of alleged "sinkholes".

## 2.0 METHODS

Methods outlined in this section pertain to the sampling of the Peace River, the flowing well and Nixon's old domestic well. Methods pertaining to other components of the Peace River Oils #1 Well study are outlined in Appendices 7 to 10.

### 2.1 PEACE RIVER OILS #1 WELL SAMPLING

Peace River Oils #1 Well was sampled on four occasions by the Environmental Quality Monitoring Branch to assess the quality of the outflowing water: May 17 and October 4, 1988, and March 1 and May 24, 1989. The first two samples were collected in the course of synoptic survey work on the Peace River, whereas the latter two were collected as part of the study of the flowing well. On these dates grab samples were collected for the analysis of major inorganic and organic constituents, nutrients, and metals. A complete list of field procedures and analytical methods is given in Appendix 1. Analyses of routine chemistry samples of the Peace River Oils #1 Well, and of other samples

collected in this study were performed by Chemex Labs Inc. However, samples collected in more recent surveys (conducted in July and August 1989) were analyzed at the Alberta Environmental Centre (AEC).

Samples for the analysis of trace organic compounds were collected on all dates except March 1, 1989. Both volatile and semi-volatile trace organic compounds listed in Appendix 2 and 3 were analyzed following the United States Environmental Protection Agency analytical protocols (USEPA 1986.). All trace organic constituents were analyzed by AEC.

On August 9, 1989, samples were taken for hydrocarbon quantification (electronic integration with gas chromatograph and carbon counter), and finger printing (time basis over 45 minute period). Samples for volatile and semi-volatile priority pollutants and for Microtox testing[1] were collected as well. Data were interpreted according to the CCREM (1987) guidelines because they are user specific.

## 2.2 SAMPLING OF NIXON'S OLD DOMESTIC WELL

Nixon's old domestic well was sampled on two occasions (July 25 and August 9, 1989) with a peristaltic pump and new tubing equipped with a footvalve, at a depth of approximately 20 feet. A small volume of water was pumped out of the well before collecting the samples.

Sampling on July 25 included hydrocarbons, and semi-volatile priority pollutants. On August 9, 1989 samples were collected for

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[1] Microtox is a microbial assay based on the measurement of light output by luminescent bacteria. The test has been used worldwide for toxicity assessment of chemicals, complex effluents, and a wide variety of environmental samples (Dr. A.A. Qureshi, pers. comm.).

hydrocarbon finger printing, volatile and semi-volatile priority pollutants and Microtox testing.

## 2.3 PEACE RIVER WATER QUALITY SAMPLING

### 2.3.1 Water Quality in a 50 km Stretch Below the Oil Well

The Peace River was surveyed extensively for baseline water quality data from May 1988 to March 1989 as part of a larger, basin-wide synoptic survey. Although that program was not intended to assess the impact of the Peace River Oils #1 Well, some of the data can be used to assess potential, larger-scale effects of the well water on Peace River water quality. River data are available for cross-channel transects at the following locations (Figure 1 and Table 1):

1. downstream of the proposed pulp mill site and upstream of the well;
2. upstream of the Whitemud River confluence, and
3. east of Manning.

Data were collected from each site on May 17 and October 4, 1988 and March 1, 1989.

### 2.3.2 Water Quality in the Immediate Vicinity of the Oil Well

On May 24, 1989 detailed cross-channel transects for field variables were measured with a Hydrolab 4041 at the following locations in the immediate vicinity of the well (Figure 2A):

- 100 m upstream of the well
- 100 m downstream of the well
- 1 km downstream of the well

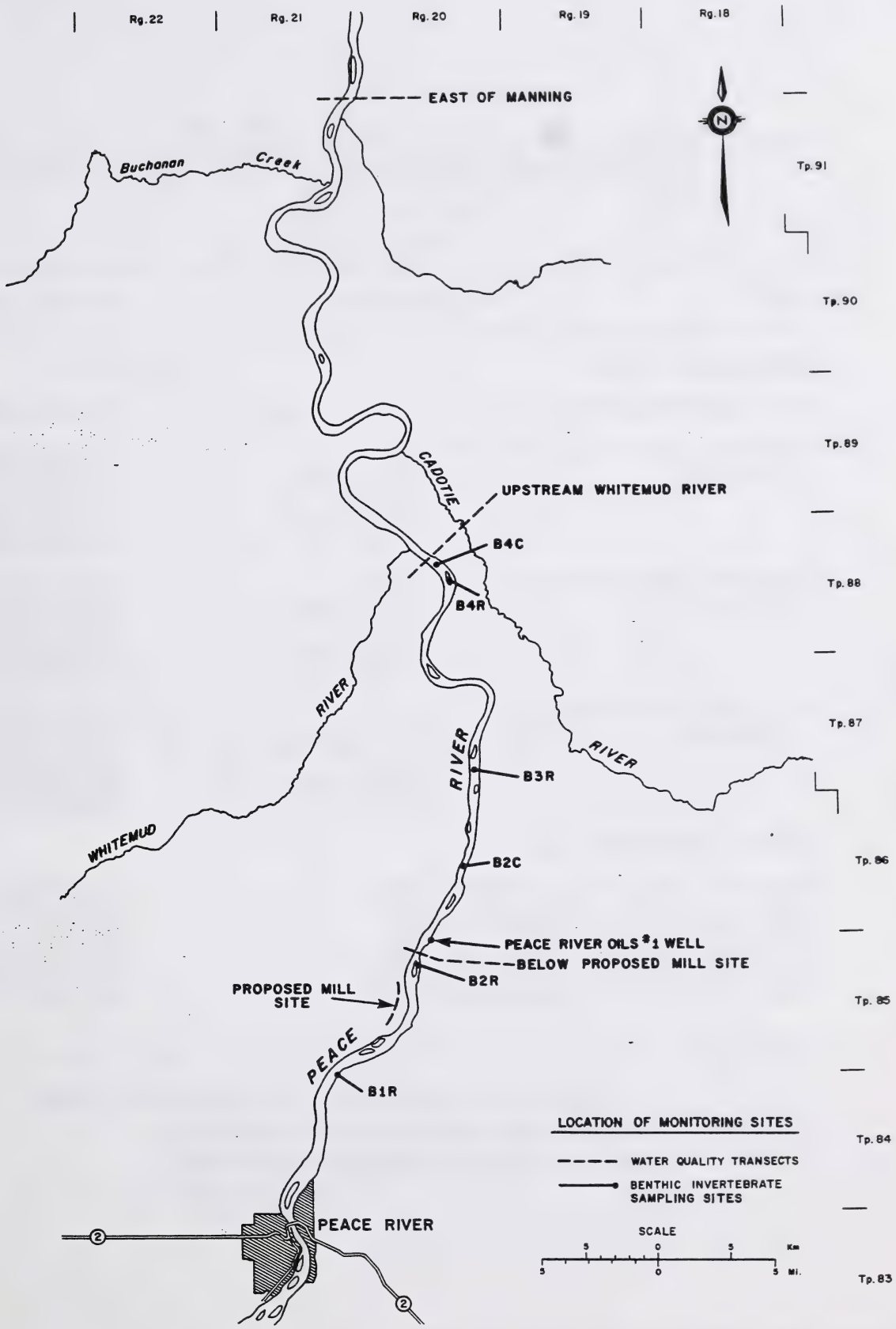


FIGURE 1 PEACE RIVER: LOCATION OF WATER QUALITY AND BENTHIC INVERTEBRATE MONITORING SITES PERTINENT TO THE PEACE RIVER OILS #1 WELL STUDY.

TABLE 1. NAQUADAT (Environment Canada, 1986) Codes and Site Description of Peace River Monitoring Sites Pertinent to the Peace River Oils #1 Study

| River | Site Description | NAQUADAT Code |
|---|---|---|
| Water Quality Sites | | |
| Peace River Oils #1 Well | | 00AL07HA2400 |
| Peace River d/s Proposed Pulp Mill (Transect) | - Left | 00AL07HA2500 |
| | - Left Center | 00AL07HA2510 |
| | - Center | 00AL07HA2520 |
| | - Right Center | 00AL07HA2530 |
| | - Right | 00AL07HA2540 |
| Peace River Above Whitemud River (Transect) | - Left | 00AL07HA2800 |
| | - Left Center | 00AL07HA2810 |
| | - Center | 00AL07HA2820 |
| | - Right Center | 00AL07HA2830 |
| | - Right | 00AL07HA2840 |
| Peace River East of Manning (Transect) | - Left | 00AL07HC1000 |
| | - Left Center | 00AL07HC1010 |
| | - Center | 00AL07HC1020 |
| | - Right Center | 00AL07HC1030 |
| | - Right | 00AL07HC1040 |
| Benthic Invertebrate Sites | | |
| Peace River 4 km u/s Proposed Mill (B1R) | | 00AL07HA2100 |
| Peace River 2 km d/s Proposed Mill (B2R) | | 00AL07HA2200 |
| Peace River 7 km d/s Proposed Mill (B2C) | | 00AL07HA2620 |
| Peace River 20 km d/s Proposed Mill (B3R) | | 00AL07HA2660 |
| Peace River 32 km d/s Proposed Mill (B4R) | | 00AL07HA2680 |
| Peace River 33 km d/s Proposed Mill (B4C) | | 00AL07HA2700 |

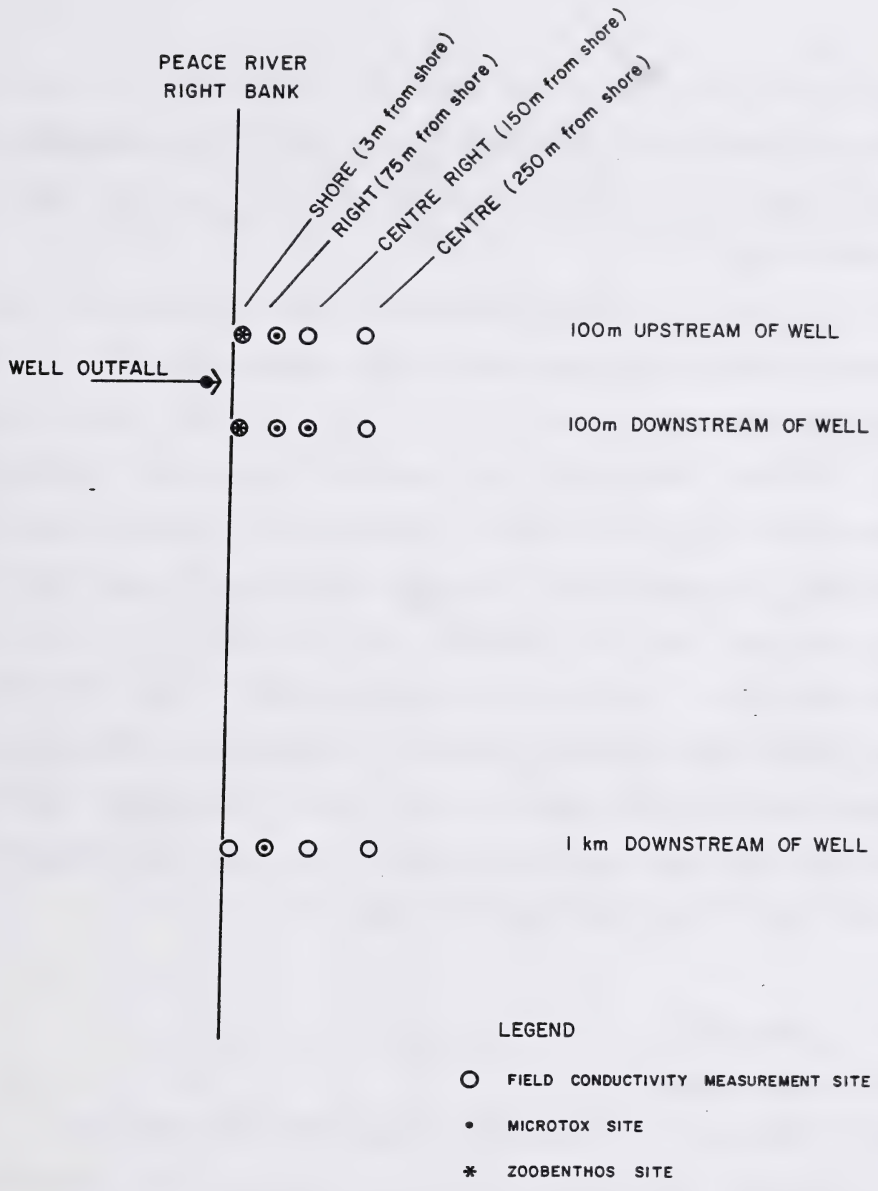


**FIGURE 2A PEACE RIVER : SCHEMATIC PRESENTATION OF SAMPLING LOCATIONS IN THE IMMEDIATE VICINITY OF THE PEACE RIVER OILS #1 WELL MAY 24, 1989.**

Samples were collected in the centre of the channel (i.e. 250 m from shore), to the right of the center channel (i.e. 150 m from shore), along the right bank (i.e., 75 m from shore), and along the right shore (i.e., 3 m from shore).

A second survey was carried out on August 9, 1989. On this occasion, conductivity measurements were carried out near the surface along cross-sectional transects as far as 13 km below the well (Figure 2B). Maximum conductivity was recorded along each cross-section. Conductivity was also recorded at fixed distances from the shore (i.e., 3 m, 30 m, 75 m, and 150 m), 100 m upstream and 100 m downstream of the well and along selected transects below the well (i.e., 1 km, 6 km, 12 km, and 13 km). A vertical profile was taken 3 m and 30 m from the shore along these selected transects. Microtox samples and hydrocarbon samples were also collected at these sites. Hydrocarbon samples for finger printing were taken 100 m upstream and 100 m downstream from the well outfall at 3 and 30 m from the shore.

## 2.4 ZOOBENTHOS

### 2.4.1 Field Methods

#### 2.4.1.1 Zoobenthos in a 30 km Stretch Downstream of the Oil Well

Benthic invertebrate surveys were part of the 1988-89 basin synoptic survey carried out on the Peace River. Note that benthic invertebrate and water quality sites do not necessarily correspond and that water quality samples were collected further downstream. Some of the benthic invertebrate data collected on October 4, 1988 are pertinent to the Peace River Oils #1 Well study as the sampling sites are located

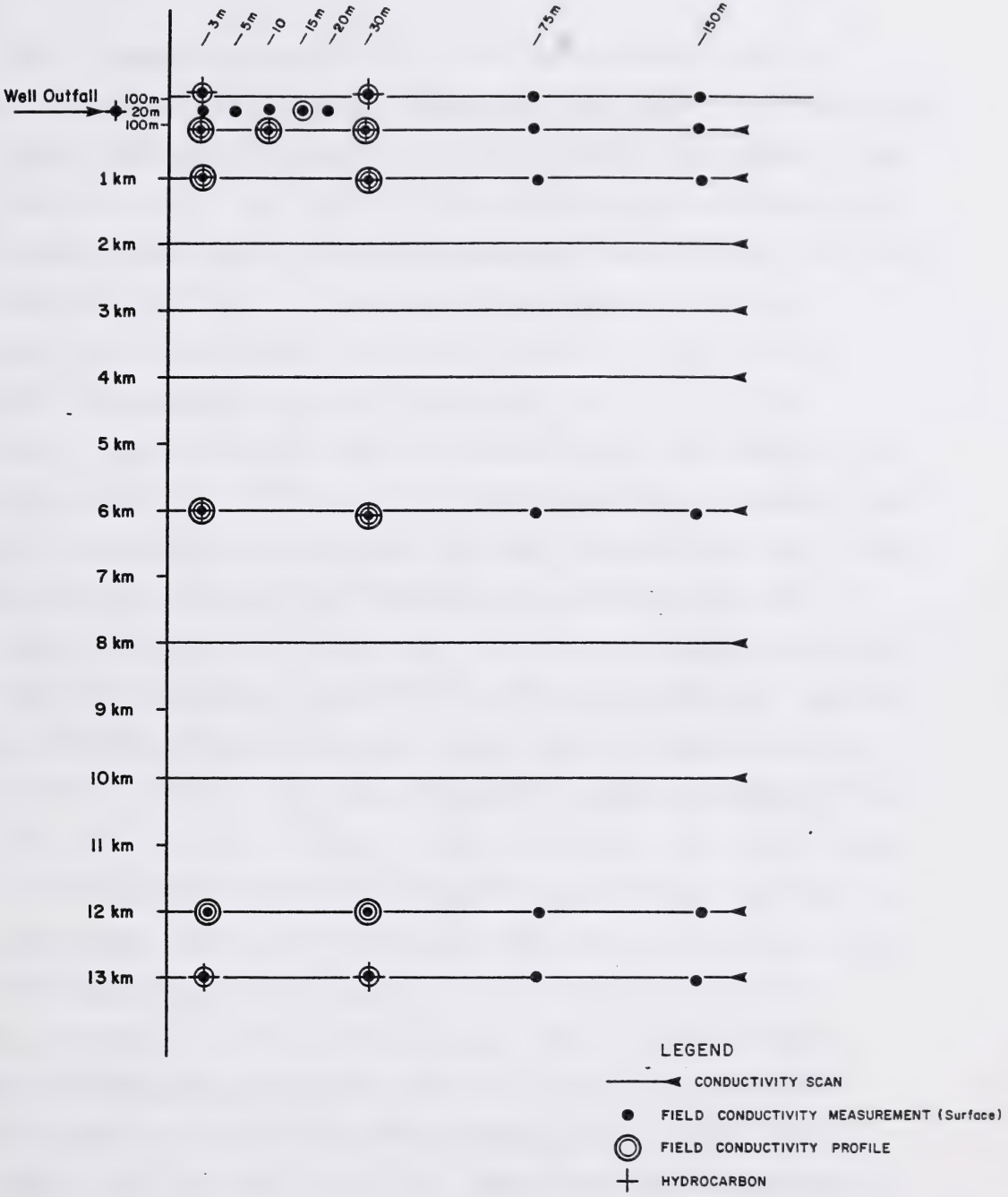


**FIGURE 2B PEACE RIVER : SCHEMATIC PRESENTATION OF SAMPLING LOCATIONS IN IMMEDIATE VICINITY OF THE PEACE RIVER OILS #1 WELL - AUGUST 9, 1989.**

in the presumed mixing zone of the well water (Figure 1). If impacts from the well water are severe, benthic invertebrates will respond by changes in population density, community composition and species diversity (number of taxa).

A Neill cylinder sampler (area 0.1 $m^2$) equipped with a collecting net of 0.210 mm mesh aperture was used to collect five replicate samples at each site. The habitat sampled was erosional gravel and cobble. The substrate within the cylinder was thoroughly disturbed for 1 minute and larger rocks were individually cleaned into the cylinder. Samples were preserved in 4% formaldehyde. Although efforts were made to standardize sampling sites with regard to substrate, depth, and current velocity, inter-site differences which could induce differences in zoobenthos are often unavoidable. In order to document such differences, measurements of sampling depth, flow velocity, and substrate size distribution (expressed as % of total weight) were carried out for every replicate and averaged to represent the sampling site.

2.4.1.2 Zoobenthos in the Immediate Vicinity of the Oil Well

On May 24, 1989 two sets of five Ekman dredges (22.5 cm x 22.5 cm) were collected in the immediate vicinity of the well (i.e., 100 m upstream and 100 m downstream of the well). Samples were collected from fine, silty substrate which dominates the river bed near the well site. Samples were sieved in the field (0.400 mm mesh size) and preserved in 4% formaldehyde.

### 2.4.2 Laboratory Methods

Invertebrates samples were stationed with Rose Bengal (Mason and Yevich 1967). Invertebrates were sorted under a dissecting scope. Specimens were counted and identified according to Bauman et al. (1977), Edmunds et al. (1976), Merritt and Cummins (1984), Pennak (1978) and Wiggins (1977).

### 2.4.3 Data Analysis

Several benthic invertebrate descriptors were examined since reliance on only one may lead to mis-interpretation. Variables taken into consideration include: total number of invertebrates, total number of taxonomic groups and the distribution of major taxonomic groups.

When a benthic community is affected by effluent discharges, changes may occur in the number of taxa and/or the density of organisms. An effluent with an enrichment effect could induce increases in population densities and taxonomic diversity whereas a toxic effluent could have the opposite effect. Hocutt (1975) believes that a simple ordination of numbers of invertebrates against number of taxa can describe such effects and can be used to assess stress in a benthic invertebrate community.

## 3.0 RESULTS AND DISCUSSION

Results presented in this section pertain to the analyses of samples from the Peace River, the flowing well and the old domestic well. Results of other components of the Peace River Oils #1 Well study are presented in Appendices 7 to 10.

## 3.1 PEACE RIVER OILS #1 WELL WATER QUALITY

### 3.1.1 Routine Chemistry

Results of well water analyses for May 1988 to May 1989 are listed in Tables 2 to 6. The well water which enters the Peace River has very high sodium and chloride ion concentrations with means of 11950 mg/L $Na^+$ and 17463 mg/L $Cl^-$. The bicarbonate concentration is also fairly high (mean: 3147 mg/L), but concentrations of other major ions are not elevated. The high sodium and chloride ion concentrations account for the high total dissolved solids (TDS) concentration which is of the order of 32,000 mg/L. Because of this high salt concentration the water that flows out of the well is classified as saline (McNeely et al. 1978). Associated with the high ionic concentrations is a specific conductance value of approximately 60,000 µmhos/cm.

The water also contains high concentrations of barium (mean 35.38 mg/L), boron (mean 12.95 mg/L), lithium (mean 4.458 mg/L), strontium (mean 51.88 mg/L) and ammonia (mean 25.62 mg/L). Sulphide was also present, at concentrations of 0.76 and 3.33 mg/L. Other water quality parameters listed in Table 2 were not at concentrations of concern.

Because of its high salt concentration the well water would be totally unsuitable for irrigation of most crops (CCREM 1987). The salt concentration is high enough to affect aquatic biota, but considering the high dilution capacity of the Peace River, effects would likely be very localized (see Section 3.4).

Boron is transported into solution through the weathering of igneous and sedimentary rocks. Concentrations in the well water exceeded

TABLE 2. Peace River Oils #1 Well: Water Quality Data

| Parameter Description | NAQUADAT Code | May 17/88 | Oct. 4/88 | March 1/89 | May 24/89 |
|---|---|---|---|---|---|
| Calcium | 20103L | 127.00 | 19.70 | 87.00 | 211.00 |
| Magnesium | 12102L | 147.00 | 108.00 | 153.00 | 160.00 |
| Sodium | 11103L | 11500.00 | 12000.00 | 12600.00 | 11700.00 |
| Potassium | 19103L | 158.00 | 172.00 | 154.00 | 148.00 |
| Chloride | 17203L | 18050.00 | 17400.00 | 17200.00 | 17200.00 |
| Sulphate | 16306L | 57.9 | 81.0 | 174.0 | 120.0 |
| PP Alkalinity as $CaCO_3$ | 10151L | 623.0 | L 0.1 | L 0.1 | L 0.1 |
| Total Alkalinity as $CaCO_3$ | 10101L | 2613.00 | 2970.00 | 3130.00 | 2860.00 |
| pH | 10301L | 9.66 | 7.73 | 8.16 | 8.10 |
| Carbonate | 06301L | 747.6 | L 0.5 | L 0.5 | L 0.5 |
| Bicarbonate | 06201L | 1666.4 | 3620.4 | 3815.5 | 3486.3 |
| Total Hardness as $CaCO_3$ | 10602L | 922.6 | 493.8 | 847.2 | 1186.1 |
| Hydroxide | 08501L | - | L 0.5 | L 0.5 | L 0.5 |
| Fluoride | 09107L | 1.52 | 1.75 | 2.30 | 1.70 |
| Silica, Reactive | 14105L | 5.00 | 4.30 | 4.54 | 2.77 |
| Specific Conductance | 02041L | 61600.00 | - | - | 59900.00 |
| Turbidity | 02074L | 1.9 | 0.4 | 20.0 | 18.0 |
| Colour (True) | 02021L | L 5. | 20. | 10. | 5. |
| Oil & Grease - Freon (IR) | 06521L | L 0.1 | 3.3 | 3.6 | 0.3 |
| Cyanide | 06608L | L 0.1 | 3.3 | 3.6 | 0.3 |
| Phenols | 06537L | 0.150 | 0.002 | 0.160 | 0.140 |
| Sulphide | 16200L | - | - | 3.33 | 0.76 |
| Total Organic Carbon | 06005L | 7.0 | 9.3 | 7.11 | 8.0 |
| Dissolved Organic Carbon | 06104L | 6.6 | 8.7 | 6.2 | 7.7 |
| Total Ammonia Nitrogen | 07505L | 27.00 | 25.50 | 16.00 | 34.00 |
| Total Kjeldahl Nitrogen | 07015L | 28.00 | 27.80 | 27.20 | 34.50 |
| Nitrite Nitrogen as N | 07206L | L 0.003 | - | - | - |
| Nitrite Nitrate Nitrogen as N | 07110L | L 0.003 | - | - | - |
| Total Phosphorus as P | 15406L | 0.012 | 0.007 | 0.010 | 0.010 |
| Total Filterable Residue | 10451L | 31650. | 31600. | 32300. | 31300. |
| Non-Filterable Residue | 10401L | 50.0 | 10.8 | 15.6 | 28.4 |
| Aluminum | 13003L | 0.03 | 0.02 | 0.02 | 0.02 |
| Antimony | 51103L | 0.0011 | L 0.0002 | L 0.0002 | L 0.0002 |
| Arsenic | 33005L | L 0.0002 | 0.0005 | 0.0012 | L 0.0002 |
| Barium | 56001L | 32.00 | 29.00 | 40.00 | 40.50 |
| Beryllium | 04002L | 0.005 | L 0.001 | L 0.001 | 0.001 |
| Boron | | 13.00 | 13.20 | 12.00 | 13.60 |
| Cadmium | 48002L | L 0.001 | L 0.001 | L 0.001 | L 0.001 |
| Chromium | 24004L | L 0.001 | L 0.001 | L 0.001 | 0.002 |
| Cobalt | 27002L | L 0.001 | L 0.001 | L 0.001 | L 0.001 |
| Copper | 29005L | 0.001 | L 0.001 | 0.004 | L 0.001 |
| Iron | 26004L | - | 0.02 | - | 0.17 |
| Lead | 82002L | | L 0.002 | L 0.002 | L 0.002 |
| Lithium | 03001L | 5.100 | 5.170 | 5.450 | 2.110 |
| Manganese | 25004L | 0.054 | 0.040 | 0.048 | 0.040 |
| Mercury | 80011L | L 0.05 | L 0.05 | L 0.05 | L 0.05 |
| Molybdenum | 42006L | 0.013 | 0.007 | 0.001 | L 0.001 |
| Nickel | 28002L | 0.001 | L 0.001 | L 0.001 | L 0.001 |
| Selenium | 34005L | L 0.0002 | L 0.0002 | 0.0003 | L 0.0002 |
| Silver | | L 0.001 | L 0.001 | 0.002 | 0.002 |
| Strontium | 38001L | 50.00 | 55.50 | 41.00 | 61.50 |
| Vanadium | 23002L | 0.003 | L 0.001 | L 0.001 | 0.001 |
| Zinc | 30005L | 0.005 | 0.007 | 0.003 | L 0.001 |
| Ion Balance | 00103L | 0.93 | 0.97 | 1.03 | 0.99 |
| Peace River Discharge | | 3450 | 1340 | 1010 | 1770 |
| Dilution Effluent in River | | 1:8620 | 1:33500 | 1:25250 | 1:44250 |

* units are mg/L, except for pH (pH units), Specific Conductance (µmhos/cm), Turbidity (NTU), Colour (PtCo Units) and Discharge ($m^3/s$)
* estimated discharge at oil well: 0.04 $m^3/s$

TABLE 3. Peace River Oils #1 Well: Semi-Volatile Compounds (µg/L) Identified in the Well Water

| NAQUADAT NUMBER | | MAY 17 1988 | OCT. 9 1988 | MAY 24 1989 |
|---|---|---|---|---|
| 95000 | Benzoic Acid | 2.U | 2.U | 2.U |
| 95001 | 4-Chloro-3-Methylphenol | 1.U | 1.U | 1.U |
| 95002 | 2-Chlorophenol | 2.U | 2.U | 2.U |
| 95003 | 2,4-Dichlorophenol | 1.U | 1.U | 1.U |
| 95004 | 2,4-Demethyl Phenol | 0.X | 2.U | 2.U |
| 95005 | 2-Methyl-4, 6-Dinitrophenol | 1.U | 1.U | 1.U |
| 95006 | 2,4-Dinitrophenol | 1.U | 1.U | 1.U |
| 95007 | Hexadecanoic Acid | 3.U | 3.U | 4. |
| 95008 | 2-Nitrophenol | 1.U | 1.U | 1.U |
| 95009 | 4-Nitrophenol | 1.U | 1.U | 1.U |
| 95010 | Pentachlorophenol | 1.U | 1.U | 1.U |
| 95011 | Phenol | 0.X | 1.U | 1.U |
| 95012 | 2,4,5-Trichlorophenol | 1.U | 1.U | 1.U |
| 95013 | 2,4,6-Trichlorophenol | 1.U | 1.U | 1.U |
| 95014 | Acenaphthene | 1.U | 1.U | 1.U |
| 95015 | Acenaphthylene | 1.U | 1.U | 1.U |
| 95016 | Anthracene | 0.X | 1.U | 1.U |
| 95017 | Benz(a)Anthracene | 1.U | 1.U | 1.U |
| 95018 | Benzo(k)Fluoranthene | 1.U | 1.U | 1.U |
| 95019 | Benzo(ghi)Perylene | 2.U | 2.U | 2.U |
| 95020 | Benzo(a)Pyrene | 1.U | 1.U | 1.U |
| 95021 | Chrysene | 1.U | 1.U | 1.U |
| 95022 | Dibenzo(ah)Anthracene | 5.U | 5.U | 5.U |
| 95023 | Fluoranthene | 1.U | 1.U | 1.U |
| 95024 | Fluorene | 1.U | 1.U | 1.U |
| 95025 | Indeno(1,2,3-cd)Pyrene | 1.U | 1.U | 1.U |
| 95026 | Naphthalene | 0.X | 0.X | 1.U |
| 95027 | Perylene | 1.U | 1.U | 1.U |
| 95028 | Phenanthrene | 0.X | 1.U | 1.U |
| 95029 | Pyrene | 1.U | 1.U | 1.U |
| 95031 | Benzo(b)Fluoranthene | 1.U | 1.U | 1.U |
| 95032 | 2-Chloronaphthalene | 0.X | 1.U | 1.U |
| 95033 | Hexachlorobenzene | 1.U | 1.U | 1.U |
| 95034 | Hexachlorobutadiene | 5.U | 5.U | 5.U |
| 95035 | Hexachlorocyclopentadiene | 1.U | 1.U | 1.U |
| 95036 | Hexachloroethane | 5.U | 5.U | 5.U |
| 95037 | 1,2,4-Trichlorobenzene | 1.U | 1.U | 1.U |
| 95030 | Isophorone | 1.U | 1.U | 1.U |
| 95038 | Benzidine | 2.U | 2.U | 2.U |
| 95039 | 2,4-Dinitrotoluene | 1.U | 1.U | 1.U |
| 95040 | 2,6-Dinitrotoluene | 1.U | 1.U | 1.U |
| 95041 | 1,2-Diphenylhydrazine | 1.U | 1.U | 1.U |
| 95042 | Nitrobenzene | 1.U | 1.U | 1.U |
| 95043 | N-Nitrosodiphenylamine | 1.U | 1.U | 1.U |
| 95044 | N-Nitroso-Di-n-Propylamine | 2.U | 2.U | 2.U |
| 95045 | 4-Bromophenyl Phenyl Ether | 1.U | 1.U | 1.U |
| 95046 | Bis(2-Chloroethoxy)Methane | 1.U | 1.U | 1.U |
| 95047 | Bis(2-Chloroethyl)Ether | 1.U | 1.U | 1.U |
| 95048 | Bis(2-Chloroisopropyl)Ether | 1.U | 1.U | 1.U |
| 95049 | 4-Chlorophenyl Phenyl Ether | 1.U | 1.U | 1.U |
| 95050 | Butylbenzylphthalate | 1.U | 1.U | 1.U |
| 95051 | Dibutylphthalate | 0.X | 1.X | 1.X |
| 95052 | Diethylphthalate | 0.X | 1.U | 0.X |
| 95053 | Dimethylphthalate | 1. | 1.U | 1.U |
| 95054 | Di-n-Octylphthalate | 1.U | 1.U | 1.U |
| 95055 | Bis(2-Ethylhexyl)-Phthalate | 1.U | 1.U | 1.U |

* U indicates compound was not detected; detection limit specified.
  X indicates compound was detected; concentration specified.

TABLE 4. Peace River Oils #1 Well: Volatile Compounds (µg/L) Identified in the Well Water

| NAQUADAT NUMBER | | MAY 17 1988 | OCT. 9 1988 | MAY 24 1989 |
|---|---|---|---|---|
| 95200 | Benzene | 1 | 0.X | 1.X |
| 95230 | Bromochloromethane | 1.U | 1.U | |
| 95201 | Bromodichloromethane | 1.U | 1.U | 1.U |
| 95202 | Bromoform | 5.U | 5.U | 5.U |
| 95203 | Bromomethane | 1.U | 1.U | 1.U |
| 95204 | Carbontetrachloride | 1.U | 1.U | 1.U |
| 95205 | Chlorobenzene | 1.U | 1.U | 1.U |
| 95206 | Chloroethane | 1.U | 1.U | 1.U |
| 95207 | 2-Chloroethoxyethylene | 4.U | 4.U | 4.U |
| 95208 | Chloroform | 3. | 1.U | 1.U |
| 95209 | Dibromochloromethane | 1.U | 1.U | 1.U |
| 95211 | 1,2-Dichlorobenzene | 1.U | 1.U | 1.U |
| 95212 | 1,3-Dichlorobenzene | 1.U | 1.U | 1.U |
| 95213 | 1,4-Dichlorobenzene | 1.U | 1.U | 1.U |
| 95214 | 1,1-Dichloroethane | 1.U | 1.U | 1.U |
| 95215 | 1,2-Dichloroethane | 1.U | 1.U | 1.U |
| 95216 | 1,1-Dichloroethylene | 1.U | 1.U | 1.U |
| 95217 | trans-1,2-Dichloroethylene | 1.U | 1.U | 1.U |
| 95218 | 1,2-Dichloropropane | 1.U | 1.U | 1.U |
| 95219 | cis-1,3-Dichloropropylene | 3.U | 3.U | 3.U |
| 95220 | trans-1,3-Dichloropropylene | 3.U | 3.U | 3.U |
| 95221 | Ethylbenzene | 1.U | 1.U | 0.X |
| 95222 | Methylene Chloride | 1.8 | 4.8 | 2.8 |
| 95223 | Styrene | 1.U | 1.U | 1.U |
| 95224 | 1,1,2,2-Tetrachloroethane | 1.U | 1.U | 1.U |
| 95225 | Tetrachloroethylene | 3.U | 3.U | 3.U |
| 95226 | Toluene | 1.U | 1.U | 1.U |
| 95227 | 1,1,1-Trichloroethane | 1.U | 1.U | 1.U |
| 95228 | 1,1,2-Trichloroethane | 1.U | 1.U | 1.U |
| 95231 | Trichloroethylene | 1.U | 1.U | 1.U |
| 95229 | Trichlorofluoromethane | 1.U | 1.U | 1.U |
| 95232 | Vinyl Chloride | 30.U | 30.U | 30.U |
| 95233 | o-Xylene | 1.U | 1.U | 1.U |
| 95234 | m,p-Xylene | 1.U | 1.U | 1.U |

* U indicates compound was not detected, detection limit specified.
X indicates compound was detected, concentration specified.

TABLE 5. Peace River Oils #1 Well: Tentatively Identified Compounds

| | COMPOUNDS | µg/L |
|---|---|---|
| | **VOLATILE COMPOUNDS** | |
| May 17, 1988 | 1) Alkyl Benzenes (6-8 Isomers C9H12 Range) | 5.X |
| | 2) Dihydromethyl Naphthalenes | 2.X |
| October 9, 1988 | 1) N-Nitrosodiphenylamine | 0.X |
| | **SEMI-VOLATILE COMPOUNDS** | |
| May 17, 1988 | 1) Methyl Naphthalenes | 4.X |
| | 2) 2-Haptanone-3-Propylidene | 2.X |
| | 3) Sulphur (S6) | 20.X |
| | 4) Sulphur (S8) | 2.X |
| October 10, 1988 | 1) Hydrocarbons | 600.X |

* X indicates compound was detected, concentration specified.

TABLE 6. Peace River Oils #1 Well: Hydrocarbons Identified in the Well Water

| | | |
|---|---|---|
| May 1988 | Hydrocarbon (Crude Oil) | 0.32 mg/L |
| October 1988 | Hydrocarbon (Crude Oil) | 0.57 mg/L |
| July 1989 | Hydrocarbon (Crude Oil) | 31.2 mg/L |
| August 1989 | Hydrocarbon (Crude Oil) | 2.3 mg/L |

agricultural guidelines proposed by CCREM (1987) for irrigation (i.e. 6.0 mg/L) and livestock watering (i.e. 5.0 mg/L) as well as the Alberta Surface Water Quality Objectives (i.e. 0.5 mg/L). There are no CCREM guidelines for the protection of aquatic life, but McNeely et al. (1978) indicate that concentrations greater than 5.0 mg/L constitute a hazard to the marine environment. Boron concentrations in the Peace River were 0.03 and 0.04 mg/L at the site above Whitemud River on June 20, 1988 and March 1, 1989, respectively. Such concentrations are well within guidelines.

Lithium leaches easily from rocks and sediments and occurs in association with sodium in aqueous solution (McNeely et al. 1978). High lithium concentrations can be phytotoxic and guidelines of 2.5 mg/L or less are proposed by CCREM for irrigation water. The well water generally exceeded this guideline. There are no data regarding the Peace River lithium concentration in the area of the well. Lithium concentrations at Dunvegan ranged from <0.005 to 0.021 mg/L (NAQUADAT database). The predicted concentration increase of lithium, based on a conservative mass balance, in the Peace River, corresponds to 0.0002 mg/L (March 1, 1989 low flow) or to 0.00006 mg/L (May 17, 1989 high flow).

Barium weathers from igneous rocks and usually occurs in trace amounts in groundwater. Barium salts are highly toxic to humans and guidelines for drinking water have been set at 1.0 mg/L. There are no CCREM guidelines for agricultural usage. Although no guidelines exist for the protection of aquatic life, high concentrations of barium can affect rooted aquatic plants and many fish species (McNeely et al. 1979). Concentrations greater than 5 mg/L are harmful to many species of

fish (Environment Canada 1976, cited in McNeely et al. 1979). Barium concentrations in the well water were usually greater than 30.0 mg/L. In the Peace River concentrations above Whitemud River were 0.10 mg/L and 0.05 mg/L on June 20, 1988 and March 1, 1989, respectively. Based on a conservative mass balance, the contribution of barium from the flowing well would have amounted to an overall increase of 0.002 mg/L on March 1, 1989.

Strontium enters the aquatic environment through weathering of sedimentary rocks. There are no CCREM guidelines for strontium for drinking water, agricultural usage or protection of aquatic life. There are no data regarding the strontium concentration of Peace River water in the vicinity of the well. Strontium concentrations were monitored at Dunvegan from 1971 to 1980 and ranged from 0.05 to 0.25 mg/L (NAQUADAT database). Based on a conservative mass balance, the Peace River Oils #1 Well would have accounted for an overall concentration increase of 0.002 mg/L at low flow (March 1, 1989) or 0.0006 mg/L at high flow (May 17, 1989).

Un-ionized ammonia can be extremely toxic to fish and freshwater invertebrates. The toxicity of un-ionized ammonia varies with the pH and temperature, and the proportion of total ammonia that is un-ionized also varies with pH and temperature (CCREM 1987). Total ammonium nitrogen levels in the well water ranged from 16.00 to 34.00 mg/L. Considering the temperature and pH at which the samples were collected, ammonia levels in the oil well effluent should have remained under 2.5 mg/L to meet CCREM guidelines. Total ammonia measured in the Peace River along cross-channel transects upstream of the well, upstream of Whitemud River,

and east of Manning never exceeded 0.02 mg/L and were often below detection (i.e, <0.01 mg/L).

Hydrogen sulphide is a soluble, highly poisonous gas. Its toxicity is primarily related to the undissociated hydrogen sulphide ($H_2S$ molecule). In natural waters sulphide ions rapidly oxidize to sulphate and concentrations are generally negligible in surface waters. There are no guidelines for the protection of aquatic life, but McNeely et al. (1979) indicate that hydrogen sulphide concentrations in excess of 0.002 mg/L are hazardous to fish and aquatic life. Because hydrogen sulphide readily oxidizes it is seldom monitored in surface waters and it is unlikely that toxicity problems would occur in the Peace River, with perhaps the exception of the area immediately below the outfall.

According to CCREM (1987) guidelines concentrations of total phenols should not exceed 0.001 mg/L to prevent tainting of fish flesh. Concentrations in the well water were usually in excess of this value and ranged from 0.002 mg/L to 0.160 mg/L.

### 3.1.2 Trace Organics

A number of trace organic compounds were also identified in the well water (Table 3 to 6). These include traces of organic priority pollutants such as chloroform, benzene, phenol, other phenolic compounds, and polycyclic aromatic hydrocarbons. Methylene chloride is a solvent used commonly in laboratories; concentrations shown in Table 4 are due to contamination in the lab and do not reflect concentrations in the oil well effluent. A list of tentatively identified volatile and semi-volatile compounds is presented in Table 5. Relatively little

information is available regarding their toxicity and no guidelines have been formulated for the protection of aquatic life. Consequently it is difficult to assess what the implications are of the traces found in the well water.

### 3.1.3 Microtox Testing

The three samples for Microtox testing collected from the oil well on May 24, 1989 and August 9, 1989 were extremely toxic. The sample concentration causing a 50% decrease in light production at 15°C after 15 minute exposure (15 min EC50) ranged from 3.2 to 7.3% (Table 7).

## 3.2 WATER QUALITY OF NIXON'S OLD DOMESTIC WELL

### 3.2.1 Routine Water Chemistry

Samples for routine water chemistry were collected by the Groundwater Protection Branch and results are discussed elsewhere (de Brentani 1989).

### 3.2.2 Trace Organics

Levels of hydrocarbons detected in Nixon's old domestic well ranged from 0.75 mg/L (August 9, 1989) to 1.2 mg/L (July 25, 1989). These hydrocarbons contained a light fraction (i.e., C6 to C8 or C9) which was not present in any other sample from the oil well or the Peace River. However, less volatile, heavier hydrocarbons (i.e. C12) matched the hydrocarbons found in the Peace River Oils #1 Well water sample. Heavier hydrocarbons from the domestic well and from the oil well are suspected to be from the same origin (R. Norton, Alberta Environmental

TABLE 7. Results of Microtox Test on Water From the Peace River Oils #1 Well, Nixon's Old Domestic Well, and the Peace River - Summarized from Reports Produced by Alberta Environmental Centre in Vegreville Under Supervision of Dr. A.A. Qureshi

| Site Description | Microtox (Mx) 15 Min.EC50% Original Sample % | Toxicity Rank |
|---|---|---|
| Peace River Oils #1 Well (PRO#1) | | |
| May 24, 1989 | | |
| Replicate 1 | 3.2 | extremely toxic |
| Replicate 2 | 6.5 | extremely toxic |
| August 9, 1989 | 7.3 | extremely toxic |
| Nixon's Old Domestic Well | | |
| August 9, 1989 | | |
| Replicate 1 Duplicate 1 | 26.8 | very toxic |
| Duplicate 2 | 29.1 | very toxic |
| Replicate 2 | 15.0 | extremely toxic |
| Peace River | | |
| May 24, 1989 | | |
| 100 m u/s PRO #1 right bank | NTE | nontoxic |
| 100 m d/s PRO #1 right bank | NTE | nontoxic |
| 100 m d/s PRO #1 right-centre | NTE | nontoxic |
| 1 km d/s PRO #1 right bank | NTE | nontoxic |
| August 9, 1989 | | |
| 100 m u/s PRO #1, 3 m from shore | NTE | nontoxic |
| 100 m u/s PRO #1, 30 m from shore | NTE | nontoxic |
| 100 m d/s PRO #1, 3 m from shore | NTE | nontoxic |
| 100 m d/s PRO #1, 10 m from shore | NTE | nontoxic |
| 100 m d/s PRO #1, 30 m from shore | NTE | nontoxic |
| 1 km d/s PRO #1, 3 m from shore | NTE | nontoxic |
| 1 km d/s PRO #1, 30 m from shore | NTE | nontoxic |
| 6 km d/s PRO #1, 3 m from shore | NTE | nontoxic |
| 6 km d/s PRO #1, 30 m from shore | NTE | nontoxic |
| 13 km d/s PRO #1, 3 m from shore | NTE | nontoxic |
| 13 km d/s PRO #1, 30 m from shore | NTE | nontoxic |

NTE - no toxic effect

Centre, pers. comm.) The analysis of semi-volatile priority pollutants revealed the presence of traces of phenol in the domestic well water.

### 3.2.3 Microtox Testing

The two samples from Nixon's old domestic well were analyzed separately. One sample was analyzed in duplicate and produced 15 minutes EC50's of 26.8% and 29.1%. The second sample had a 15 minute EC50 of 15%. Based on these EC50 values, the two samples were classified as very to extremely toxic (Table 7).

## 3.3 PEACE RIVER WATER QUALITY

### 3.3.1 Water Quality in a 50 km Stretch Below the Oil Well

As mentioned earlier (Methods section), the 1988-89 synoptic survey of the Peace River was not designed specifically to assess the impacts of the Peace River Oils #1 Well. As a result, many constituents which are typical of the well water have not been monitored in the river and a detailed assessment of the effects of the well water on the Peace River is not possible. There are some additional complicating factors in the assessment. The water volume discharged from the well is very small relative to that of the Peace River (1 to 10,000 at low river flow). The dilution factor is so large that for many constituents the contributions of the well would not be measurable in the river, particularly considering the long distance between the well and the first Peace River site for which extensive water quality data are available. The potential for interference from other sources such as natural flowing gas wells along the river is also considerable. Finally, some constituents of

concern in the well water are unstable and oxidize rapidly to innocuous constituents common in the receiving water.

Sodium and chloride are conservative ions which occur at high concentrations in the well water and which have been monitored along transects in the Peace River. Theoretically, the data could be used to determine lateral and longitudinal mixing patterns of saline well water in the Peace River which has low sodium and chloride concentrations. However, the mixing patterns of the Smoky and Whitemud rivers, both with sodium and chloride concentrations higher than the Peace River, overshadow the mixing patterns of the well water. Concentrations of chloride in the well are higher than concentrations of sodium in the well, but in the Peace River, chloride concentrations are lower than sodium concentrations. Therefore any effect of the well outflow on river concentrations should be more noticeable for chloride. Indeed, on all sampling occasions, chloride increased at all points along the transects upstream of Whitemud River compared to corresponding points along the transect upstream of the well (Table 8). The increases, about 0.2 - 1.5 mg/L, is consistent with the dilution of the well outflow (at 17,500 mg/L and 0.04 $m^3/s$) into the Peace River (at about 1800 $m^3/s$). Thus some overall increase in Peace River chloride may result from the well outflow, but the resulting concentrations would not affect the general water quality.

Conductivity measured in the immediate vicinity of the well provides a better indication of the oil well effluent mixing in the river.

TABLE 8. Peace River: Cross-channel $Na^+$ and $Cl^-$ Concentrations ($mg \cdot L^{-1}$) and Specific Conductance ($\mu S \cdot cm^{-1}$) in the Vicinity of Peace River Oils #1 Well (May 24, 1989)

| | $Na^+$ | | | | | $Cl^-$ | | | | | Conductivity | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | LC | C | RC | R | L | LC | C | RC | R | L | LC | C | RC | R |
| May 17, 1988 | | | | | | | | | | | | | | | |
| Below proposed pulp mill effluent | 3.20 | 3.20 | 3.20 | 3.50 | 3.80 | 0.50 | 0.50 | 0.50 | 0.80 | 1.10 | 199 | 199 | 199 | 205 | 207 |
| Upstream Whitemud | 2.60 | 2.80 | 3.00 | 3.50 | 3.80 | 0.60 | 0.70 | 1.00 | 1.30 | 1.70 | 196 | 199 | 201 | 203 | 206 |
| East of Manning | 4.30 | 4.20 | 4.30 | 4.20 | 4.20 | 1.20 | 1.00 | 0.90 | 0.80 | 0.80 | 209 | 208 | 208 | 208 | 208 |
| October 4, 1988 | | | | | | | | | | | | | | | |
| Below proposed pulp mill effluent | 2.10 | 2.40 | 3.00 | 4.90 | 6.20 | 1.00 | 0.90 | 2.10 | 3.30 | 4.30 | 188 | 191 | 205 | 242 | 263 |
| Above Whitemud River | 2.70 | 3.50 | 4.70 | 5.20 | 5.80 | 1.60 | 1.90 | 2.90 | 3.90 | 4.40 | 194 | 207 | 222 | 228 | 232 |
| East of Manning | 3.40 | 3.70 | 3.90 | 4.10 | 4.40 | 2.20 | 2.40 | 2.50 | 2.80 | 3.10 | 207 | 206 | 213 | 217 | 220 |
| March 1, 1989 | | | | | | | | | | | | | | | |
| Below proposed pulp mill effluent | 1.60 | 1.60 | 2.40 | 4.70 | 5.20 | 1.00 | 0.90 | 1.80 | 3.60 | 4.20 | 177 | 177 | 188 | 216 | 228 |
| Above Whitemud River | 2.00 | 2.70 | 3.40 | 4.00 | 4.60 | 1.40 | 2.30 | 3.30 | 3.80 | 4.70 | 181 | 188 | NA | 200 | 202 |
| East of Manning | 2.30 | 2.40 | 2.60 | 3.20 | 3.90 | 2.10 | 1.90 | 2.20 | 2.90 | 3.50 | 140 | 185 | 185 | 195 | 199 |

L left bank
LC left centre
C centre channel
RC right centre
R right bank

### 3.3.2 Water Quality in the Immediate Vicinity of the Oil Well

Lateral transects in the Peace River in the immediate vicinity of Peace River Oils #1 Well show that there was a sharp increase in conductivity 100 m downstream of the well on the right bank (i.e. approximately 75 m from shore) (Table 9). Conductivity was lower on the right bank 1 km below the well, but remained elevated along the shoreline.

On August 9, 1989 conductivity measurements along cross-channel transects showed elevated values in a 40 m wide zone along the right bank of the river. Highest conductivity readings near the surface were recorded immediately below the well outfall (i.e., 100 m downstream) at about 10 m from the shore (Table 10). Slight cross-channel conductivity gradients could still be detected as far downstream as 13 km below the well outfall.

Vertical profiles showed the existence of sharp gradients in the immediate vicinity of the well outfall with conductivity values at the bottom nearly twice as high as values near the surface of the water column (Table 10). Such gradients were not detected 1 km below the well or at any of the remaining sites further downstream.

Conductivity data indicate that the Peace River Oils #1 Well plume travels close to the right bank of the Peace River, mixes slowly with the river water, and can be traced over at least 13 km downstream of the outfall.

Apparently, the Peace River Oils #1 Well effluent sinks to the bottom upon its entry in the Peace River, but vertical mixing occurs a lot faster (less than 1 km) than lateral mixing. Surveys carried out in the vicinity of the well at relatively low and high Peace River discharge

TABLE 9. Peace River: Lateral Variability of Conductivity ($\mu S \cdot cm^{-1}$) in the Vicinity of Peace River Oils #1 Well, May 24, 1989

| | Conductivity | | | |
|---|---|---|---|---|
| | Distance from Shore | | | |
| Distance from Oils #1 Well | 3 m (Shore) | 75 m (Right) | 150 m (Right Centre) | 250 m (Centre) |
| 100 m upstream | N/A | 212 | 213 | 213 |
| 100 m downstream | 306 | 300 | 213 | 216 |
| 1 km downstream | 301 | 263 | 213 | 217 |

TABLE 10. Peace River: Lateral and Vertical Variability of Conductivity in the Vicinity of Peace River Oils #1 Well, August 9, 1989

Conductivity ($\mu S \cdot cm^{-1}$)

| Distance From Oils #1 Well | Distance From Shore | | | | | | | | | Maximum Recorded Near Surface Along Transect |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 m | 5 m | 10 m | 15 m | 20 m | 30 m | 40 m | 75 m | 150 m | |
| 100 m u/s | 207 | | | | | 207 | | 205 | 202 | 207 |
| 20 m d/s | 254 | 246 | 261 | 0*:280<br>.5:495 | 209 | | | | | |
| 100 m d/s | 0:262<br>.5:274 | | 0:305<br>1:320 | | | 0:226<br>1:426<br>2:453 | 209 | 206 | 203 | 340 |
| 1 km d/s | 0:308<br>.5:299 | | | | | 0:254<br>1:253<br>1.5:246 | | 206 | 200 | 308 |
| 2 km d/s | | | | | | | | | | 268 |
| 3 km d/s | | | | | | | | | | 258 |
| 4 km d/s | | | | | | | | | | 249 |
| 6 km d/s | 0:244<br>1:245<br>1.5:244 | | | | | 0:227<br>1:226<br>2:225<br>2.5:224 | | 205 | 201 | 240 |
| 8 km d/s | | | | | | | | | | 226 |
| 10 km d/s | | | | | | | | | | 220 |
| 12 km d/s | 0:218<br>1:218<br>1.5:218 | | | | | 0:210<br>1:213<br>2:213<br>3:213 | | | | 220 |
| 13 km d/s | 219 | | | | | 217 | | 206 | 201 | 219 |

(*) depth in metres

suggest that lateral mixing patterns of the plume may differ depending on river flows. At the relatively low river discharge of 1770 $m^3/s$ (May 24, 1989), the effluent plume was broader than at the higher discharge of 2747 $m^3/s$ measured on August 9, 1989. The river discharge is also likely to affect the length of the plume.

3.3.2.1 Hydrocarbons

Samples collected on August 9, 1989 upstream of the well (3 m from shore) and 100 m downstream of the well (3 m and 10 m from shore) had hydrocarbon concentrations less than 0.05 mg/L. Finger printing showed that samples collected downstream of the well matched the sample collected above the well. In other words, contamination of the Peace River by the well effluent could not be demonstrated.

3.3.2.2 Microtox Testing

Microtox test results showed that all samples collected in the Peace River 100 m upstream of the well, and all samples collected downstream of the well outfall on May 24 and August 9, 1989 were non-toxic (Table 7). As discussed earlier, there are several constituents in the well water which occur at potentially toxic concentrations. The salinity of the well water could affect aquatic life forms adapted to fresh water and salinity could be a factor in the results obtained with trout bioassays by the ERCB in October 1985 (Appendix 4). However, it is unlikely that Microtox test organisms which are marine bacteria would be affected by the 3% salt concentration of the well water (Dr. R. Coleman, Alberta Environmental Centre, pers. comm.).

This statement is substantiated by the toxic response in Nixon's old domestic well, where the water is not saline. This suggests that constituents other than salts may be responsible for the toxicity. The Microtox test is non-specific and it is not possible to determine which constituent(s) account for toxicity. Levels of ammonia, sulphide, boron, barium, strontium and organic pollutants could induce toxic responses in Microtox organisms as single constituents or in combination (synergistic effects).

The absence of toxic response in the Peace River indicates that toxicity for Microtox organisms has dissipated through dilution or chemical transformations.

## 3.4 ZOOBENTHOS

### 3.4.1 Zoobenthos in a 30 km Stretch Below the Oil Well

When environmental stress such as a change in water quality affects benthic invertebrate communities, a change in population density, number of taxa and/or species composition may result. The simple ordination of total density against number of taxa proposed by Hocutt (1975) is useful in the recognition of stressed invertebrate communities.

Figure 3 presents such an ordination for the Peace River monitoring data. The two sites above the well (B1R and B2R) have a considerably larger population density and a somewhat higher number of taxa than any of the other sites. However, Table 11 illustrates the variability in physical habitat among benthic sampling sites, and Figure 4 shows that there is a strong positive relationship between population density and the proportion of cobble in the substrate. This

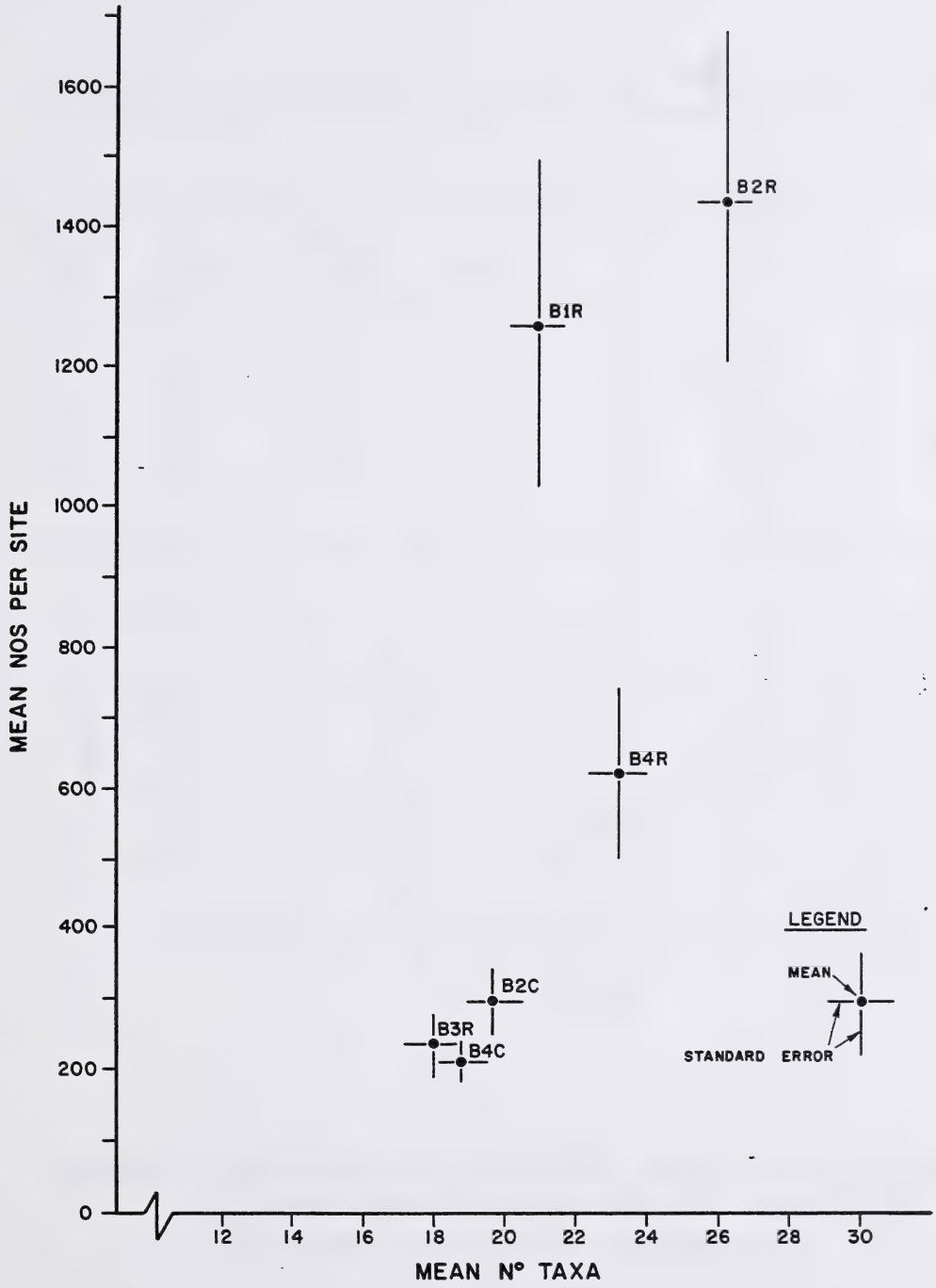


FIGURE 3 PEACE RIVER ZOOBENTHOS, OCTOBER 1988 : ORDINATION OF THE NUMBER OF INVERTEBRATE TAXA AND THE NUMBERS OF SPECIMENS.

TABLE 11. Peace River: Flow, Depth, and Substrate Characteristics at the Benthic Invertebrate Monitoring Sites (mean per site, n = 5)

| | FLOW m/s | DEPTH cm | % COBBLE | % COARSE PEBBLE | % FINE PEBBLE | % SAND SILT |
|---|---|---|---|---|---|---|
| B1R | 0.203 | 36.0 | 75.34 | 17.81 | 4.11 | 2.74 |
| B2R | 0.615 | 23.2 | 64.29 | 25.00 | 7.14 | 3.57 |
| B2C | 0.537 | 21.8 | 53.73 | 37.12 | 4.12 | 1.03 |
| B3R | 0.708 | 20.0 | 46.31 | 39.60 | 11.41 | 2.68 |
| B4R | 0.626 | 35.8 | 61.74 | 34.90 | 3.36 | 0 |
| B4C | 0.586 | 33.4 | 19.21 | 48.78 | 22.56 | 9.45 |

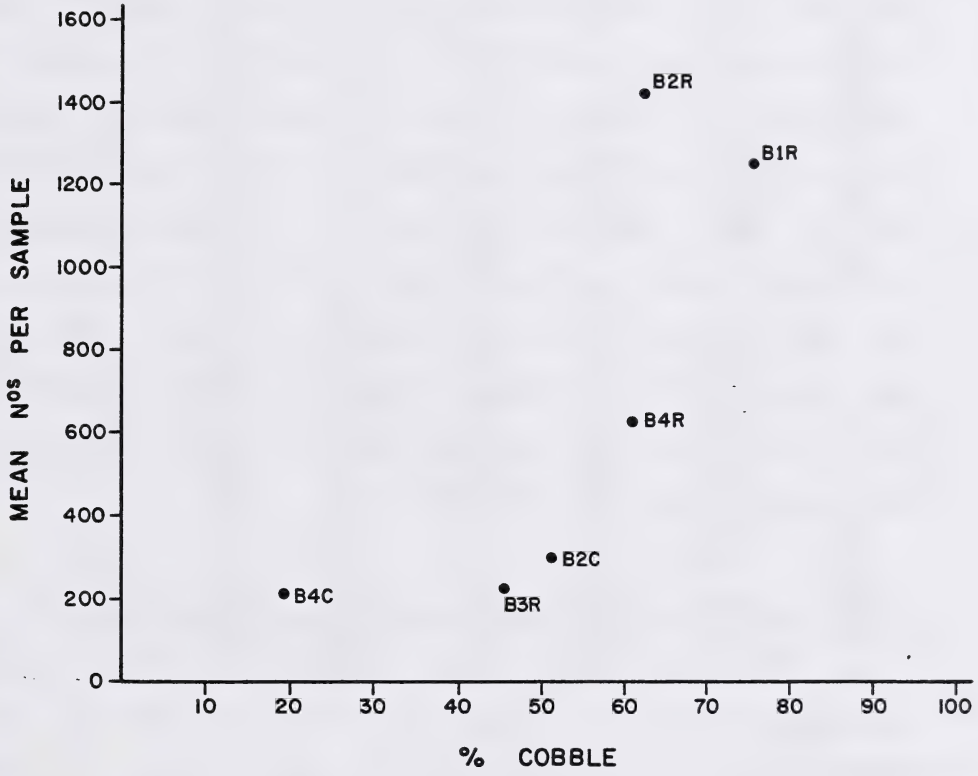


FIGURE 4 · PEACE RIVER, OCTOBER 1988 : RELATIONSHIP BETWEEN THE MEAN NUMBER OF INVERTEBRATES PER SITE AND THE PERCENT OF COBBLE IN THE SUBSTRATE.

concurs with the findings of Clement (1987) who, in addition, reports a positive relationship between substrate size and number of taxa. The relationship between the number of taxa and substrate characteristics was not as clear in our data set and there was some overlap in the number of taxa per site at sites upstream and downstream of the well. Therefore, it is probably that the differences in total density and number of taxa among sites are linked to differences in physical habitat; it is unlikely that the well water affects the zoobenthos at the sites monitored in the fall of 1988. Additional features in the zoobenthos support this assessment. Mayfly and stonefly species are generally believed to be very sensitive to a variety of changes in their environment, including water quality. Figure 5 shows that these taxa are not adversely affected at the monitoring sites as their density is often considerably higher downstream than upstream of the well.

### 3.4.2 Zoobenthos in the Immediate Vicinity of the Oil Well

The ordination of numbers against taxa (Figure 6) separates samples collected 100 m downstream of the well sharply from those collected 100 m upstream of the well, mainly because the number of taxonomic groups was considerably lower below the well. According to Hocutt's criteria, the fauna below the well site showed signs of stress. Additional features of the zoobenthos 100 m downstream of the well point in the same direction: tubificid worms and chironomid larvae represented 94% of the benthos (Figure 7): naidid worms, nematodes and ceratopogonids were the only other taxa present in the samples. Tubificidae and aquatic life stages of some Chironomidae are burrowing organisms and their

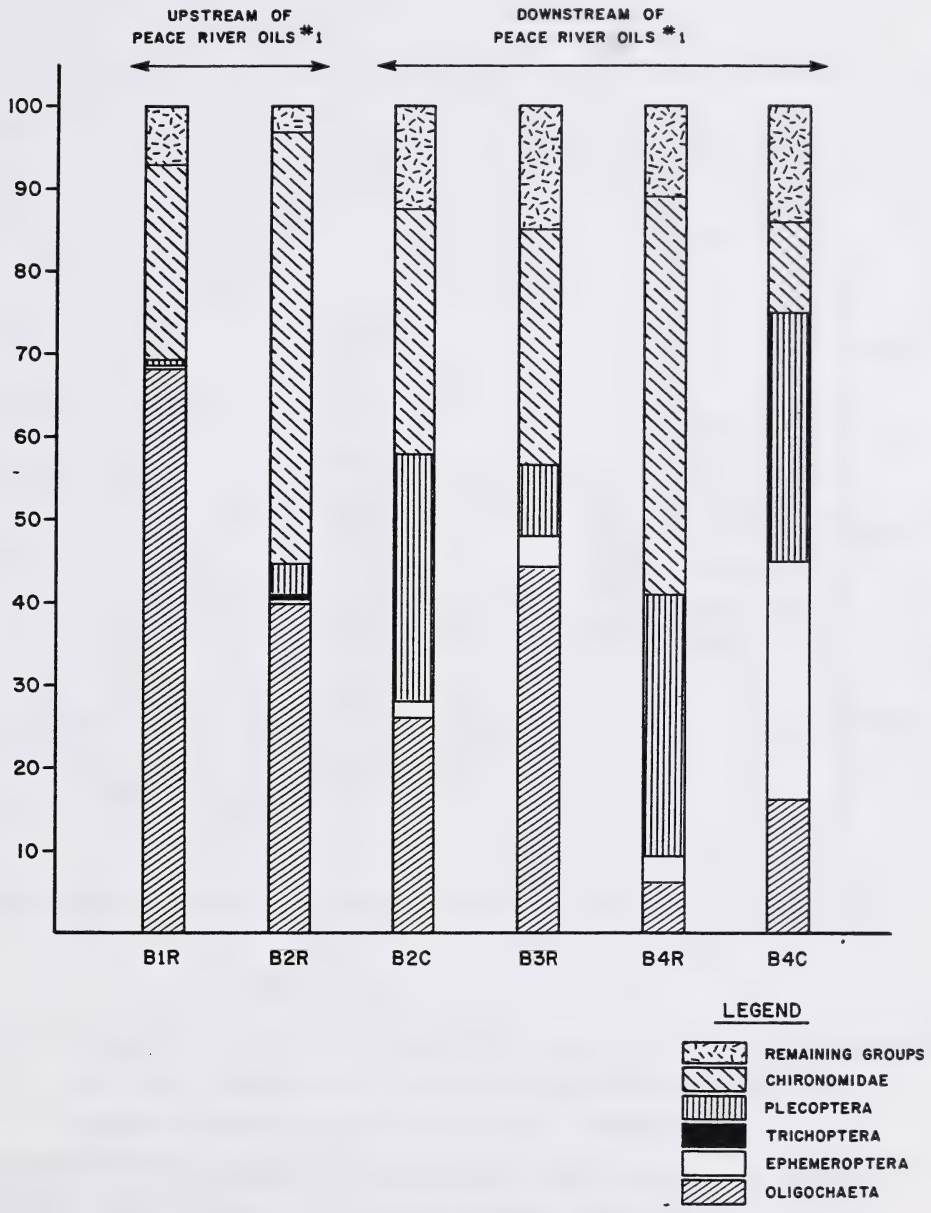


FIGURE 5 PEACE RIVER, OCTOBER 1988: PERCENT CONTRIBUTION OF MAJOR BENTHIC INVERTEBRATE GROUPS TO TOTAL NUMBERS.

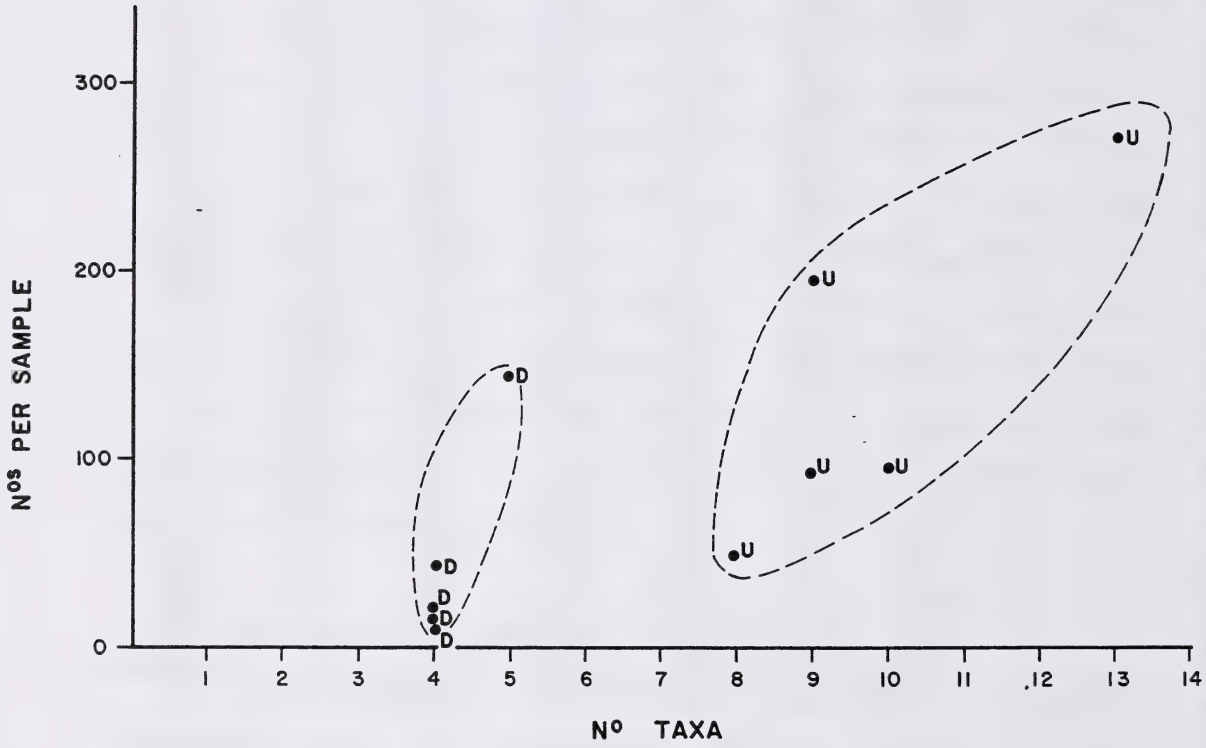


FIGURE 6 PEACE RIVER IN THE IMMEDIATE VICINITY OF PEACE RIVER OILS #1 WELL: ORDINATION OF THE NUMBER OF INVERTEBRATE TAXA AND THE NUMBER OF SPECIMENS COLLECTED 100m UPSTREAM (U) AND 100m DOWNSTREAM (D) OF THE WELL MAY 24, 1989.

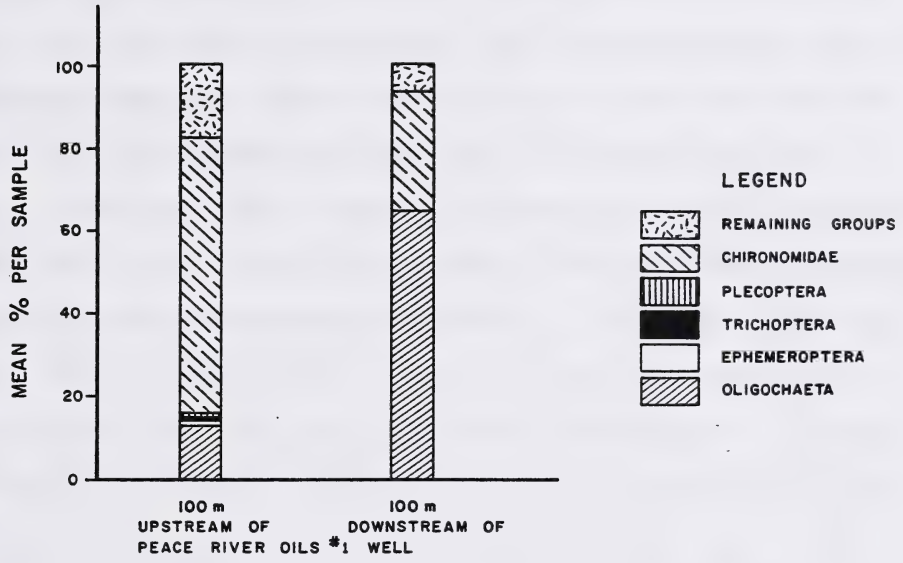


FIGURE 7 PEACE RIVER IN THE IMMEDIATE VICINITY OF PEACE RIVER OILS #1 WELL : PERCENT CONTRIBUTION OF MAJOR BENTHIC INVERTEBRATE GROUPS TO TOTAL NUMBERS MAY 24, 1989.

presence in soft riverine sediment is quite normal. However, these taxa are also known to be tolerant of a wide range of environmental conditions and they can survive under conditions which are unsuitable to most other organisms. The dominance of tubificids and chironomids in the samples collected 100 m below the well may be an indication that such unsuitable conditions exist below the well. Most samples collected 100 m above the well had higher numbers of tubificids and chironomids, but many other invertebrates were also present. These included Limoniinae (Tipulidae), Hydroptylidae (Trichoptera), Baetidae (Ephemeroptera), Perlodidae and Capniidae (Plecoptera), Cyclopoidae, and Pseudoscorpiones. Unlike the situation described for the synoptic survey sites (3.4.1) the sites sampled in the immediate vicinity of the well were quite similar and differences in habitat should not account for differences in zoobenthos.

## 4.0 SUMMARY AND CONCLUSIONS

1. In addition to very high sodium and chloride concentrations, the Peace River Oils #1 Well effluent contains several organic and inorganic constituents which exceed CCREM (1987) guidelines for the protection of aquatic life and irrigation of agricultural land. According to Microtox tests, the effluent is extremely toxic.

2. The oil well effluent appears to have only minor localized effects on the quality of the Peace River. A slight overall increase in chloride concentration of the river results from the inflow of well effluent. Biological effects, as manifested by the zoobenthos, appear localized as well.

3. High chloride levels, the presence of phenols, the similarity between hydrocarbons found in the domestic and in the oil well, and the results of Microtox tests suggest that the domestic well at Nixon's farm may be contaminated.

4. Topsoils and subsoils in the vicinity of the well are contaminated with sour smelling gas and salts. Crops are least productive in contaminated areas.

5. Intrusion of saltwater in deeper soil zones (i.e., 3 and 6 m) and in groundwater could not be shown. The well cannot be regarded as the cause for the alleged "sinkholes".

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# APPENDICES

APPENDIX 1 Water Quality Parameters and Analytical Methods

| Parameter | Container | Preservation | Analytical Code | Analytical Method Or Instrument |
|---|---|---|---|---|
| Field Analysis | | | | |
| Temperature | | | 02061F | Field meter |
| pH | | | 10301F | Field meter |
| Conductance | | | 02041F | Field meter |
| Oxygen, dissolved | | | 08101F | Field meter |
| Lab Analysis | | | | |
| pH | P | Cool to 4°C | 10301L | Meter |
| Ca | P | Cool to 4°C | 20110L | Automated atomic absorption |
| Mg | P | Cool to 4°C | 12303L | Atomic absorption, direct aspiration |
| Na | P | Cool to 4°C | 11103L | Flame photometer |
| K | P | Cool to 4°C | 19103L | Flame photometry, internal standard |
| $HCO_3$ | | | 06201L | Calculated |
| Cl | P | Cool to 4°C | 17203L | Colourimetry, ferric ammonium sulfate and mercuric thiocyanate |
| $SO_4$ | P | Cool to 4°C | 16306L | Colourimetry, $BaCl_2$ and methylthymol blue |
| $SiO_2$ | P | Cool to 4°C | 14102L | Heteropoly blue colourimetry |
| F | P | Cool to 4°C | 09107L | Automated potentiometric method |
| Conductance | P | Cool to 4°C | 02041L | Meter |
| Total dissolved solids | | | 00205L | Calculated |
| T. hardness | | | 10602L | Calculated, as $CaCO_3$ |
| Total alkalinity | P | Cool to 4°C | 10101L | Potentiometric titration |
| Total residue | | | 10474L | Calculated |
| Filterable residue | P | Cool to 4°C | 10453L | Gravimetric |
| Non filterable Residue | P | Cool to 4°C | 10407L | Gravimetric (0.45 $\mu$m filter) |
| $NO_2+NO_3$-N | P | Cool to 4°C | 07105L | Colourimetry on autoanalyzer |
| Nitrite-N | P | Cool to 4°C | 07205L | Colourimetry on autoanalyzer |
| Ammonia-N | P | 2ml 5% $H_2SO_4$ | 07562L | Colourimetric analysis |
| Total Phosphorous | P | 2ml 5% $H_2SO_4$ | 15421L | Colourimetry on autoanalyzer |
| Total Kjeldahl Nitrogen | P | 2ml 5% $H_2SO_4$ | 07021L | Colourimetry on autoanalyzer |
| T. Nitrogen, particulate | P | | 07906L | Thermal conductivity |
| Biochemical oxygen demand | G | Cool to 4°C | 08202L | 5 day, 20°C |
| Chemical oxygen demand | P | 2ml 5% $H_2SO_4$ | 08304L | Semi-automated colourimetry |
| C, dissolved organic | P | Cool to 4°C | 06107L | Colourimetry |
| C, dissolved inorganic | P | Cool to 4°C | 06154L | Colourimetry |
| C, Total | P | Cool to 4°C | 06905L | Thermal conductivity |
| Phenols | G | 1:1 $H_2SO_4$ | 06537L | Automated 4-aminoantipyrine colourimetry |

APPENDIX 1 Cont'd

| | | | | |
|---|---|---|---|---|
| Oil and Grease | G | 1:1 $H_2SO_4$ | 06524L | Freon extraction and IR spectrophotometry |
| Fe (extr) | P | Cool to 4°C | 26304L | Atomic absorption, direct aspiration |
| Cr +6 (diss.) | P | 1:1 $HNO_3$ | 24101L | Colourimetric with diphenylcarbazide |
| Hg (total) | P | $HNO_3$-$K_2Cr_2O_7$ | 80015L | Flameless atomic absorption |
| Co (total) | P | 1:1 $HNO_3$ | 27009L | Atomic emission spectrometry (ICAP) |
| Cu (total) | P | 1:1 $HNO_3$ | 29009L | ICAP method |
| Ni (total) | P | 1:1 $HNO_3$ | 28009L | ICAP method |
| Cd (total) | P | 1:1 $HNO_3$ | 48009L | ICAP method |
| Pb (extr.) | P | 1:1 $HNO_3$ | 82302L | Atomic absorption, solvent extraction |
| Zn (total) | P | 1:1 $HNO_3$ | 30009L | ICAP method |
| Mn (total) | P | 1:1 $HNO_3$ | 25003L | ICAP method |
| Cr (total) | P | 1:1 $HNO_3$ | 24009L | ICAP method |
| Be (extr) | P | 1:1 $HNO_3$ | 04304L | Atomic absorption, solvent extraction |
| V (total) | P | 1:1 $HNO_3$ | 23009L | ICAP method |
| Mo (total) | P | 1:1 $HNO_3$ | 42009L | ICAP method |
| Al (extr) | P | 1:1 $HNO_3$ | 13306L | Atomic absorption, solvent extraction |
| Se (total) | P | 1:1 $HNO_3$ | 34005L | Goulden and Brooksbank (1974) method |
| As (total) | P | 1:1 $HNO_3$ | 33005L | Goulden and Brooksbank (1974) |
| Bo (total) | P | 1:1 $HNO_3$ | - | |
| Ba (total) | P | 1:1 $HNO_3$ | 56001L | |
| Li (total) | P | 1:1 $HNO_3$ | 03001L | |
| Sr (total) | P | 1:1 $HNO_3$ | 38001L | |

P - polyethylene container G- Glass container
Analytical codes and methods: see Environment Canada (1986), and Alberta Environment (1981).

## APPENDIX 2 Priority Pollutant Analysis Methodology

D. Smillie
Alberta Environmental Centre, Chemistry Wing

The method employed for extractable priority pollutants in the MD&RS Section is based on the EPA Method 625 and covers the analysis of a number of organics that are partitioned into an organic solvent and are amenable to capillary gas chromatography/mass spectrometry (GC/MS). The method for purgeable priority pollutants is based on EPA Method 624 and deals with organics that are purged from water onto a trap, then desorbed and analyzed by capillary GC/MS.

The surface water is collected in the field directly into pretreated one litre amber sample bottles and stored in a refrigerator at 2-5°C until the time of analysis. The entire one litre volume of sample is serially extracted with methylene chloride at a pH greater than 11 and again at a pH less than 2 using a separatory funnel. The methylene chloride extracts are dried and concentrated, ready for GC/MS analysis.

Mass spectrometric/gas chromatographic analysis permit the separation and measurement of the organics in the extract. Qualitative screening is performed on target compounds using the relative retention time and relative abundances of three characteristic ions from the GC/MS data of the components of the extract. A full identification of organics screened in this manner is performed using full reference spectra. Quantitative analysis is performed using a multi-internal standards technique in which the integrated areas of characteristic ions are utilized in the calculation. Unknown compounds are identified based on comparison with library spectra. Quantification of these non-target compounds (those that are not listed as priority pollutants) is accomplished by comparison of response with an appropriate internal standard.

The method employed for volatile or purgeable priority pollutants is the purge-and-trap technique. A sample volume of 200 mL is purged with an inert gas, helium. A Tenax trap adsorbs the volatile organics purged out of solution. This is followed by thermal desorption of the volatiles on the trap onto a GC column, and subsequent mass spectral analysis. Qualitative and quantitative analysis are performed in the same fashion as for extractable priority pollutants.

APPENDIX 3 Organic priority pollutants included in the trace organic contaminant analysis by Alberta Environmental Centre, 1983.

## I. Extractables
(detection limit 1 $\mu g \cdot L^{-1}$)

### ACID GROUPS
Benzoic Acid
4-Chloro-m-cresol
2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
Hexadecanoic acid
2-Nitrophenol
4-Nitrophenol
Pentachlorophenol
Phenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

### BASE NEUTRAL GROUP
Acenaphthene
Acenaphthylene
Anthracene
Benz(a)anthracene
Benzo(k)fluoranthene
Benzo(ghi)perylene
Benzo(a)pyrene
Chrysene
Dibenzo(ah)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Perylene
Phenanthrene
Pyrene

Chloroorganics
Benzo(b)Fluoranthene
2-Chloronaphthalene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
1,2,4-Trichlorobenzene

Nitroaromatics
Isophorone
Benzidine
2,4-Dinitrotoluene
2,6-Dinitrotoluene
1,2-Diphenylhydrazine
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodiphenylamine
N-Nitrosodi-n-propylamine

Halo Ethers
4-Bromophenyl phenyl ether
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
4-Chlorophenyl phenyl ether

Phthalate Esters
Butylbenzyl phthalate
Dibutylphthalate
Diethylphthalate
Dimethylphthalate
Di-n-octylphthalate
Bis(2-ethylhexyl)phthalate

## II. Volatiles (Purgeables)
detection limit 0.1 $\mu g \cdot L^{-1}$

Benzene
Bromochloromethane
Bromodichloromethane
Bromoform
Bromomethane
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethoxyethylene
Chloroform
Dibromochloromethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
trans-1,2-Dichloroethylene
trans-1,3-Dichloropropylene
Ethyl benzene
Methylene chloride
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
Trichloroethylene
1,1,1-Trichloroethane
1,2,2-Trichloroethane
Trichlorofluoromethane
o-Xylene
m,Xylene
p-Xylene
Vinyl Chloride

# APPENDIX 4

## Peace River Oils #1 Well: Results of Toxicity Tests and Chemical Analyses Conducted by the ERCB in October 1985 and October 1986

LOCATION: LSD 4 | SEC 31 | TWP 85 | RGE 20 W | M 5

SAMPLE LOCATION NAME: Peace River Oils No. 1

SAMPLED BY: V. Jones

REPRESENTING: ERCB

DATE SAMPLED: DAY 21 | MO 10 | YR 85

TREATMENT CO.:

PROBLEM: comparison check for chlorides

APPEARANCE AS RECEIVED: clear, small amount sediment. Very strong H2S odor.

APPEARANCE OF FILTRATE:

| IONS | mg/l | IONS | mg/l |
|---|---|---|---|
| F | | Mg | |
| Cl | 15,840 | Ca | |
| $NO_2$ | | Na | 11,500 |
| Br | | K | 148. |
| $NO_3$ | | Ca + Mg | 426 |
| $PO_4$ | | $NH_4$ | |
| $SO_4$ | 16 | | |
| $HCO_3$ | 3755 | | |
| $CO_3$ | | | |
| OH | | $H_2S$ | |
| T.D.S. | 30,330 | Cr | |
| pH | 6.9 | Fe | |

DATE 24 OCTOBER 1985

MICROTOX:

EC 50(5): >100

EC 50(15): >100

EC 20(5): 11

EC 20(15): 15

TROUT CHECK. dilutions

1:10 = 3 dead 66 hours
1:20 = 3 OK at 114 hours

This is too salty even for livestock - cattle, horses, swine and even sheep will be un-thrifty, fowl generally will sicken and die. It is also toxic for reasons other than salanity.

ERCB



ANALYSIS NUMBER: W32-1086

Yellow
Peace River

LOCATION: LSD 4 | SEC 31 | TWP 85 | RGE 20 | W | M 5

SAMPLE LOCATION NAME: Peace River No 1

E.R.C.B.

SAMPLED BY: Vern Jones

REPRESENTING: E.R.C.B.

DATE SAMPLED: DAY 21 | MO 10 | YR 86

TREATMENT CO.:

PROBLEM: Water flowing into Peace River. Comparison check for Chlorides. See W52-1085, W24-984, W43-684, W34-582. Complete analysis if possible. Report on well going to Board.

APPEARANCE AS RECEIVED:

APPEARANCE OF FILTRATE:

| IONS | mg/l | IONS | mg/l |
|---|---|---|---|
| [illegible] | | Mg | 52 |
| Cl | 17114 | Ca | 41 |
| $HCO_3$ | | Na | 12,400 |
| Br | | K | 143 |
| $CO_3$ | | Ca + Mg | |
| [illegible] | | $NH_4$ | |
| [illegible] | 33 | | |
| $CO_3$ | 3982. | | |
| [illegible] | 0. | | |
| OH | 0. | $H_2S$ | |
| [illegible] | 32030 | [illegible] | |
| pH | 6.9 | Fe | |

Conductivity: 47200 µs/cm
Turbidity: 6.9 N.T.U.

DATE: October 28 1986

MICROTOX: EC 50(5):

EC 50(15):

EC 20(5):

EC 20(15):

TROUT CHECK: NO

Historical data for this well are as follows:

| Lab No | Cl | T.D.S. |
|---|---|---|
| W34-582 | 17,809 | 31,340 |
| W43-684 | 18,722 | - |
| W24-984 | 16,970 | 31,830 |
| W52-1085 | 15,340 | 30,330 |
| W32-1086 | 17,114 | 32,030 |

[illegible]

# APPENDIX 5

Benthic Invertebrate Monitoring Data
Collected in October 1988 Pertinent to the
Peace River Oils #1 Well Study

PEACE RIVER - (B1R) 4 KM U/S DAISHOWA PULPMILL 00AL07HA2100

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 96 | 41 | 70 | 76 | 39 |
| Naididae | 1446 | 868 | 587 | 585 | 399 |
| Tubificidae | 41 | 40 | 19 | 17 | 13 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 1 | 0 | 0 | 2 | 1 |
| CRUSTACEA | | | | | |
| COPEPODA | | | | | |
| Cyclopoida | 0 | 1 | 0 | 1 | 0 |
| Calanoida | 0 | 0 | 1 | 0 | 1 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Ceratopogonidae | 1 | 0 | 0 | 0 | 3 |
| Chironomidae | | | | | |
| Chironomidae pupae | 0 | 0 | 16 | 4 | 0 |
| Chironomini | 244 | 37 | 104 | 168 | 44 |
| Diamesinae | 0 | 1 | 0 | 0 | 0 |
| Orthocladiinae | 78 | 24 | 102 | 158 | 20 |
| Tanypodinae | 5 | 7 | 20 | 10 | 0 |
| Tanytarsini | 119 | 24 | 165 | 154 | 28 |
| Prodiamesinae | 5 | 0 | 0 | 0 | 0 |
| Empididae | | | | | |
| Hemerodromia | 1 | 1 | 5 | 3 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 2 | 1 | 1 | 2 | 3 |
| Ephemerellidae | 0 | 0 | 2 | 0 | 0 |
| Ephemerella | 0 | 0 | 3 | 4 | 3 |
| Heptageniidae | 2 | 0 | 2 | 2 | 0 |
| Heptagenia | 1 | 1 | 7 | 1 | 0 |
| Rhithrogena | 0 | 0 | 2 | 0 | 0 |
| Stenonema | 0 | 0 | 2 | 0 | 0 |
| Ephemeroptera immatures | 1 | 0 | 0 | 0 | 0 |
| HEMIPTERA | | | | | |
| Corixidae | 0 | 1 | 0 | 0 | 0 |
| PLECOPTERA | | | | | |
| Capniidae | 6 | 0 | 9 | 1 | 1 |
| Perlodidae | 2 | 1 | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Isogenoides | 0 | 0 | 0 | 1 | 0 |
| Isoperla | 15 | 17 | 18 | 13 | 11 |
| Taeniopterygidae | 1 | 0 | 0 | 0 | 0 |
| Oemopteryx | 1 | 4 | 7 | 7 | 4 |
| Plecoptera immature | 0 | 0 | 0 | 0 | 1 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 1 | 1 | 0 | 0 | 0 |
| Hydropsychidae | 1 | 0 | 0 | 0 | 0 |
| Hydroptilidae | 0 | 0 | 0 | 0 | 1 |
| COELENTERATA | 1 | 1 | 1 | 3 | 1 |
| NEMATODA | 51 | 33 | 71 | 50 | 64 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 128 | 29 | 48 | 42 | 47 |
| Naididae | 264 | 43 | 30 | 51 | 83 |
| Tubificidae | 72 | 18 | 9 | 2 | 6 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 1 | 0 | 1 | 2 | 2 |
| CRUSTACEA | | | | | |
| COPEPODA | | | | | |
| Cyclopoida | 0 | 1 | 2 | 0 | 1 |
| Calanoida | 2 | 1 | 8 | 5 | 3 |
| INSECTA | | | | | |
| COLLEMBOLA | 0 | 0 | 0 | 1 | 0 |
| DIPTERA | | | | | |
| Ceratopogonidae | 0 | 1 | 0 | 1 | 0 |
| Chironomidae | | | | | |
| Chironomidae pupae | 8 | 4 | 0 | 8 | 4 |
| Chironomini | 32 | 48 | 13 | 16 | 41 |
| Diamesinae | 8 | 0 | 0 | 0 | 0 |
| Orthocladiinae | 103 | 136 | 104 | 128 | 124 |
| Tanypodinae | 4 | 28 | 75 | 67 | 33 |
| Tanytarsini | 671 | 469 | 544 | 758 | 730 |
| Prodiamesinae | 0 | 8 | 2 | 12 | 17 |
| Empididae | | | | | |
| Hemerodromia | 0 | 2 | 4 | 2 | 3 |
| Tipulidae | 0 | 0 | 0 | 1 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 1 | 1 | 0 | 0 | 0 |
| Ephemerellidae | | | | | |
| Ephemerella | 4 | 10 | 2 | 1 | 4 |
| Heptageniidae | 8 | 30 | 46 | 21 | 37 |
| Heptagenia | 12 | 17 | 6 | 11 | 0 |
| Rhithrogena | 0 | 9 | 3 | 8 | 2 |
| HEMIPTERA | | | | | |
| Corixidae | 19 | 4 | 4 | 5 | 7 |
| PLECOPTERA | | | | | |
| Capniidae | 7 | 11 | 15 | 10 | 8 |
| Chloroperlidae | 0 | 1 | 0 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Perlodidae | 23 | 103 | 75 | 45 | 57 |
| Isogenoides | 0 | 2 | 4 | 2 | 2 |
| Isoperla | 57 | 109 | 87 | 142 | 63 |
| Taeniopterygidae | | | | | |
| Oemopteryx | 4 | 41 | 19 | 42 | 7 |
| Plecoptera immature | 0 | 2 | 0 | 1 | 1 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 0 | 0 | 1 | 2 |
| Hydropsychidae | | | | | |
| Cheumatopsyche | 0 | 0 | 3 | 2 | 0 |
| Hydropsyche | 2 | 5 | 7 | 7 | 2 |
| COELENTERATA | 44 | 28 | 33 | 35 | 28 |
| NEMATODA | 46 | 62 | 59 | 61 | 33 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 24 | 32 | 40 | 11 | 32 |
| Naididae | 696 | 318 | 671 | 74 | 932 |
| Tubificidae | 13 | 46 | 12 | 6 | 16 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 0 | 1 | 0 | 1 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Bosminidae | | | | | |
| Bosmina | 0 | 0 | 0 | 4 | 0 |
| COPEPODA | | | | | |
| Harpacticoida | 3 | 0 | 1 | 0 | 0 |
| Calanoida | 1 | 2 | 1 | 3 | 0 |
| INSECTA | | | | | |
| COLEOPTERA | 0 | 0 | 0 | 0 | 1 |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 4 | 4 | 4 | 12 | 0 |
| Chironomini | 231 | 111 | 611 | 135 | 593 |
| Orthocladiinae | 96 | 66 | 56 | 88 | 76 |
| Tanypodinae | 12 | 37 | 0 | 20 | 24 |
| Tanytarsini | 396 | 289 | 224 | 280 | 208 |
| Prodiamesinae | 0 | 0 | 0 | 8 | 0 |
| Empididae | | | | | |
| Hemerodromia | 1 | 1 | 1 | 4 | 1 |
| Diptera adults | 0 | 0 | 1 | 0 | 1 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 4 | 1 | 0 | 4 | 1 |
| Baetis | 0 | 0 | 0 | 0 | 1 |
| Ephemerellidae | | | | | |
| Ephemerella | 6 | 2 | 8 | 7 | 13 |
| Heptageniidae | 2 | 2 | 0 | 2 | 4 |
| Heptagenia | 2 | 0 | 0 | 0 | 0 |
| Rhithrogena | 0 | 0 | 0 | 0 | 1 |
| Ephemeroptera immatures | 0 | 0 | 0 | 1 | 0 |
| HEMIPTERA | | | | | |
| Corixidae | 4 | 0 | 2 | 2 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| PLECOPTERA | | | | | |
| Capniidae | 5 | 5 | 0 | 6 | 9 |
| Chloroperlidae | 2 | 0 | 0 | 0 | 0 |
| Plecoptera immature | 0 | 1 | 0 | 0 | 1 |
| Perlodidae | 28 | 20 | 4 | 17 | 18 |
| Isogenoides | 1 | 0 | 1 | 1 | 0 |
| Isoperla | 80 | 26 | 10 | 26 | 63 |
| Taeniopterygidae | | | | | |
| Oemopteryx | 7 | 7 | 3 | 4 | 4 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 1 | 0 | 0 | 0 |
| Hydropsychidae | 0 | 2 | 0 | 2 | 2 |
| Cheumatopsyche | 5 | 9 | 0 | 13 | 2 |
| Hydropsyche | 6 | 14 | 1 | 27 | 5 |
| TERRESTRIAL INSECTS | 0 | 0 | 1 | 0 | 0 |
| COELENTERATA | 4 | 11 | 2 | 17 | 5 |
| MOLLUSCA | 0 | 0 | 1 | 0 | 2 |
| NEMATODA | 10 | 20 | 25 | 31 | 23 |
| PLATYHELMINTHES | | | | | |
| TURBELLARIA | 1 | 0 | 0 | 0 | 0 |
| TARDIGRADA | 1 | 0 | 0 | 0 | 0 |

PEACE RIVER - (B2L) 5 KM D/S DAISHOWA SITE 00AL07HA2600

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON. B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 49 | 65 | 81 | 81 | 61 |
| Naididae | 15 | 28 | 22 | 43 | 42 |
| Tubificidae | 3 | 8 | 3 | 0 | 1 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 1 | 3 | 2 | 2 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Bosminidae | | | | | |
| Bosmina | 0 | 0 | 1 | 1 | 0 |
| Chydoridae | 0 | 0 | 0 | 0 | 1 |
| COPEPODA | | | | | |
| Cyclopoida | 4 | 4 | 3 | 2 | 2 |
| Calanoida | 4 | 1 | 4 | 6 | 1 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 3 | 1 | 0 | 3 | 1 |
| Chironomini | 18 | 7 | 11 | 23 | 20 |
| Orthocladiinae | 73 | 110 | 118 | 97 | 97 |
| Tanypodinae | 8 | 8 | 24 | 20 | 13 |
| Tanytarsini | 103 | 200 | 172 | 155 | 183 |
| Prodiamesinae | 0 | 1 | 0 | 0 | 0 |
| Empididae | | | | | |
| Hemerodromia | 2 | 1 | 0 | 2 | 3 |
| Tipulidae | 0 | 0 | 0 | 1 | 0 |
| Diptera adults | 1 | 0 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 3 | 1 | 4 | 2 | 0 |
| Ephemerellidae | | | | | |
| Ephemerella | 7 | 6 | 9 | 8 | 10 |
| Heptageniidae | 4 | 12 | 29 | 27 | 13 |
| Rhithrogena | 2 | 6 | 11 | 13 | 22 |
| HEMIPTERA | | | | | |
| Corixidae | 0 | 0 | 0 | 0 | 1 |
| PLECOPTERA | | | | | |
| Capniidae | 4 | 3 | 16 | 7 | 11 |

| | | | | | |
|---|---|---|---|---|---|
| Chloroperlidae | 0 | 1 | 2 | 0 | 1 |
| Perlodidae | 77 | 193 | 268 | 262 | 257 |
| Isogenoides | 1 | 1 | 8 | 4 | 7 |
| Isoperla | 28 | 45 | 81 | 84 | 99 |
| Taeniopterygidae | | | | | |
| Oemopteryx | 22 | 55 | 77 | 47 | 65 |
| Plecoptera immature | 2 | 3 | 2 | 0 | 0 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 1 | 0 | 1 | 0 | 0 |
| Hydropsychidae | 1 | 2 | 5 | 0 | 3 |
| Cheumatopsyche | 2 | 2 | 1 | 0 | 0 |
| Hydropsyche | 1 | 4 | 4 | 8 | 7 |
| COELENTERATA | 5 | 9 | 34 | 18 | 13 |
| NEMATODA | 38 | 14 | 39 | 44 | 44 |
| PLATYHELMINTHES | | | | | |
| TURBELLARIA | 0 | 1 | 0 | 0 | 0 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 80 | 2 | 34 | 46 | 32 |
| Naididae | 17 | 45 | 111 | 21 | 7 |
| Tubificidae | 0 | 7 | 0 | 0 | 0 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 2 | 0 | 1 | 0 | 1 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 0 | 0 | 0 | 0 | 1 |
| Bosminidae | | | | | |
| Bosmina | 0 | 1 | 0 | 1 | 0 |
| COPEPODA | | | | | |
| Cyclopoida | 2 | 2 | 2 | 5 | 3 |
| Harpacticoida | 0 | 1 | 0 | 0 | 0 |
| Calanoida | 2 | 4 | 1 | 4 | 4 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 3 | 1 | 0 | 0 | 0 |
| Chironomini | 22 | 6 | 11 | 13 | 13 |
| Orthocladiinae | 94 | 33 | 70 | 38 | 61 |
| Tanypodinae | 2 | 1 | 0 | 2 | 1 |
| Tanytarsini | 22 | 7 | 14 | 5 | 9 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 2 | 0 | 0 | 2 | 1 |
| Ephemerellidae | | | | | |
| Ephemerella | 8 | 0 | 6 | 4 | 6 |
| Heptageniidae | 7 | 4 | 5 | 1 | 4 |
| Heptagenia | 1 | 0 | 0 | 0 | 0 |
| Rhithrogena | 0 | 2 | 0 | 1 | 1 |
| PLECOPTERA | | | | | |
| Capniidae | 5 | 0 | 0 | 3 | 4 |
| Perlodidae | 76 | 21 | 85 | 37 | 59 |
| Isogenoides | 1 | 0 | 0 | 0 | 2 |
| Isoperla | 15 | 9 | 12 | 9 | 12 |
| Taeniopterygidae | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Oemopteryx | 19 | 7 | 24 | 6 | 28 |
| Plecoptera immature | 1 | 0 | 0 | 0 | 1 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | | | | | |
| Hydropsyche | 0 | 0 | 1 | 0 | 0 |
| COELENTERATA | 8 | 15 | 15 | 14 | 6 |
| NEMATODA | 24 | 9 | 12 | 18 | 13 |

PEACE RIVER - (B3L) 17 KM D/S DAISHOWA PULPMILL 00AL07HA2640

SAMPLER: NEILL CYLINDRE SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 120 | 24 | 55 | 41 | 86 |
| Lumbriculidae | 0 | 1 | 0 | 0 | 0 |
| Naididae | 39 | 1 | 32 | 10 | 10 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 8 | 2 | 3 | 1 | 2 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Bosminidae | | | | | |
| Bosmina | 0 | 1 | 4 | 3 | 0 |
| COPEPODA | | | | | |
| Cyclopoida | 3 | 2 | 1 | 1 | 2 |
| Harpacticoida | 2 | 0 | 1 | 0 | 0 |
| Calanoida | 0 | 9 | 2 | 6 | 3 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 8 | 0 | 0 | 4 | 0 |
| Chironomini | 24 | 16 | 20 | 12 | 6 |
| Orthocladiinae | 140 | 92 | 104 | 96 | 24 |
| Tanypodinae | 21 | 9 | 16 | 28 | 2 |
| Tanytarsini | 497 | 300 | 404 | 490 | 67 |
| Prodiamesinae | 0 | 0 | 4 | 0 | 0 |
| Empididae | | | | | |
| Hemerodromia | 0 | 1 | 0 | 0 | 0 |
| Diptera adults | 1 | 0 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 4 | 2 | 2 | 0 | 1 |
| Ephemerellidae | | | | | |
| Ephemerella | 3 | 2 | 4 | 3 | 0 |
| Heptageniidae | 35 | 31 | 55 | 56 | 24 |
| Heptagenia | 4 | 2 | 8 | 4 | 0 |
| Rhithrogena | 12 | 27 | 1 | 26 | 2 |
| Stenonema | 0 | 0 | 0 | 1 | 0 |
| HEMIPTERA | | | | | |
| Corixidae | 0 | 0 | 1 | 0 | 0 |
| PLECOPTERA | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Capniidae | 17 | 16 | 15 | 24 | 9 |
| Chloroperlidae | 0 | 0 | 0 | 1 | 1 |
| Perlodidae | 106 | 101 | 125 | 113 | 71 |
| Isogenoides | 0 | 0 | 1 | 2 | 0 |
| Isoperla | 102 | 86 | 69 | 74 | 57 |
| Taeniopterygidae | 6 | 0 | 2 | 0 | 0 |
| Oemopteryx | 41 | 21 | 12 | 36 | 20 |
| Plecoptera immature | 2 | 1 | 3 | 3 | 3 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | 1 | 0 | 1 | 0 | 0 |
| Cheumatopsyche | 0 | 1 | 1 | 4 | 1 |
| Hydropsyche | 1 | 2 | 0 | 2 | 0 |
| COELENTERATA | 44 | 11 | 45 | 50 | 16 |
| NEMATODA | 51 | 16 | 22 | 23 | 35 |

PEACE RIVER - (B3R) 20 KM D/S DAISHOWA PULPMILL 00AL07HA2660

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 71 | 44 | 47 | 60 | 37 |
| Naididae | 159 | 39 | 11 | 53 | 28 |
| Tubificidae | 0 | 2 | 0 | 1 | 0 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 1 | 0 | 0 | 0 | 1 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 1 | 0 | 1 | 0 | 0 |
| COPEPODA | | | | | |
| Cyclopoida | 0 | 1 | 0 | 0 | 0 |
| Calanoida | 0 | 0 | 0 | 1 | 0 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 0 | 2 | 0 | 7 | 2 |
| Chironomini | 35 | 22 | 23 | 24 | 4 |
| Orthocladiinae | 32 | 28 | 32 | 32 | 15 |
| Tanypodinae | 1 | 2 | 2 | 1 | 1 |
| Tanytarsini | 28 | 28 | 19 | 31 | 16 |
| Empididae | | | | | |
| Hemerodromia | 1 | 1 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 1 | 0 | 0 | 0 |
| Ephemerellidae | | | | | |
| Ephemerella | 0 | 0 | 1 | 0 | 0 |
| Heptageniidae | 5 | 2 | 6 | 1 | 0 |
| Heptagenia | 0 | 1 | 1 | 1 | 1 |
| Rhithrogena | 1 | 1 | 1 | 0 | 1 |
| Tricorythidae | | | | | |
| Tricorythodes | 0 | 0 | 1 | 0 | 0 |
| HEMIPTERA | | | | | |
| Corixidae | 0 | 1 | 0 | 0 | 0 |
| PLECOPTERA | | | | | |
| Capniidae | 9 | 11 | 13 | 6 | 5 |
| Perlodidae | 2 | 3 | 3 | 4 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| Isoperla | 1 | 4 | 2 | 5 | 1 |
| Taeniopterygidae | | | | | |
| Oemopteryx | 2 | 5 | 2 | 4 | 0 |
| Plecoptera immature | 1 | 2 | 0 | 0 | 0 |
| COELENTERATA | 23 | 22 | 15 | 14 | 9 |
| NEMATODA | 26 | 12 | 18 | 20 | 17 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 48 | 46 | 24 | 17 | 23 |
| Naididae | 4 | 11 | 11 | 0 | 10 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 6 | 4 | 13 | 1 | 2 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 0 | 1 | 0 | 0 | 0 |
| Bosminidae | | | | | |
| Bosmina | 0 | 0 | 1 | 0 | 0 |
| COPEPODA | | | | | |
| Cyclopoida | 5 | 9 | 1 | 2 | 4 |
| Calanoida | 4 | 0 | 5 | 11 | 9 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 4 | 0 | 8 | 2 | 5 |
| Chironomini | 122 | 22 | 45 | 32 | 26 |
| Orthocladiinae | 464 | 62 | 365 | 112 | 136 |
| Tanypodinae | 0 | 7 | 8 | 3 | 6 |
| Tanytarsini | 40 | 2 | 56 | 20 | 18 |
| Empididae | | | | | |
| Hemerodromia | 0 | 0 | 0 | 2 | 0 |
| Tipulidae | 1 | 0 | 0 | 0 | 1 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 5 | 0 | 11 | 1 | 1 |
| Ephemerellidae | | | | | |
| Ephemerella | 2 | 2 | 6 | 6 | 9 |
| Heptageniidae | 9 | 4 | 15 | 6 | 7 |
| Heptagenia | 0 | 0 | 1 | 0 | 0 |
| Rhithrogena | 1 | 0 | 6 | 1 | 2 |
| PLECOPTERA | | | | | |
| Capniidae | 3 | 1 | 3 | 4 | 5 |
| Chloroperlidae | 0 | 0 | 2 | 0 | 0 |
| Plecoptera immatures | 3 | 3 | 6 | 3 | 4 |
| Perlodidae | 61 | 34 | 139 | 52 | 87 |

POLLUTION CONTROL DIVISION Oct. 4, 1988

PEACE RIVER - (B4R) 32 KM D/S DAISHOWA PULPMILL 00AL07HA2680

| | | | | | |
|---|---|---|---|---|---|
| Isogenoides | 3 | 6 | 6 | 1 | 6 |
| Isoperla | 27 | 22 | 74 | 30 | 32 |
| Taeniopterygidae | | | | | |
| Oemopteryx | 61 | 49 | 105 | 65 | 98 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | | | | | |
| Hydropsyche | 1 | 0 | 0 | 0 | 2 |
| Cheumatopsyche | 1 | 0 | 0 | 0 | 1 |
| COELENTERATA | 6 | 9 | 18 | 0 | 22 |
| NEMATODA | 41 | 55 | 21 | 48 | 25 |
| PLATYHELMINTHES | | | | | |
| TURBELLARIA | 0 | 0 | 3 | 0 | 1 |

PEACE RIVER - (B4C) 33 KM D/S DAISHOWA PULPMILL 00AL07HA2700

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 29 | 19 | 52 | 12 | 43 |
| Naididae | 5 | 0 | 6 | 4 | 14 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 0 | 1 | 0 | 0 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Bosminidae | | | | | |
| Bosmina | 0 | 1 | 0 | 1 | 0 |
| COPEPODA | | | | | |
| Cyclopoida | 1 | 1 | 1 | 6 | 2 |
| Harpacticoida | 1 | 0 | 0 | 1 | 0 |
| Calanoida | 2 | 7 | 4 | 10 | 6 |
| INSECTA | | | | | |
| COLEOPTERA | | | | | |
| Curculionidae | 0 | 1 | 0 | 0 | 0 |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomini | 15 | 9 | 13 | 10 | 14 |
| Orthocladiinae | 10 | 5 | 9 | 13 | 16 |
| Tanypodinae | 1 | 0 | 0 | 0 | 0 |
| Tanytarsini | 5 | 2 | 1 | 2 | 3 |
| Empididae | | | | | |
| Hemerodromia | 0 | 1 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 1 | 1 | 0 | 2 | 0 |
| Heptageniidae | 14 | 17 | 22 | 17 | 25 |
| Rhithrogena | 39 | 23 | 52 | 42 | 42 |
| Ephemerellidae | | | | | |
| Ephemerella | 0 | 1 | 1 | 0 | 1 |
| PLECOPTERA | | | | | |
| Capniidae | 0 | 2 | 2 | 1 | 1 |
| Chloroperlidae | 0 | 3 | 0 | 0 | 0 |
| Plecoptera immature | 0 | 0 | 2 | 0 | 0 |
| Perlodidae | 38 | 18 | 58 | 31 | 47 |
| Isogenoides | 4 | 6 | 2 | 0 | 1 |
| Isoperla | 6 | 7 | 7 | 7 | 22 |

| | | | | | |
|---|---|---|---|---|---|
| Taeniopterygidae | | | | | |
| Oemopteryx | 14 | 12 | 15 | 11 | 19 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | 0 | 0 | 0 | 1 | 0 |
| Arctopsyche | 0 | 1 | 0 | 0 | 0 |
| COELENTERATA | 24 | 7 | 28 | 15 | 14 |
| NEMATODA | 8 | 2 | 0 | 0 | 1 |
| PLATYHELMINTHES | | | | | |
| TURBELLARIA | 0 | 0 | 0 | 0 | 2 |

PEACE RIVER - (B4L) 35 KM D/S DAISHOWA PULPMILL 00AL07HA2800

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON, W.J. ANDERSON, B. JACKSON AND J. WILLIS
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 68 | 59 | 42 | 47 | 63 |
| Naididae | 54 | 60 | 34 | 35 | 44 |
| Tubificidae | 4 | 6 | 0 | 2 | 0 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 2 | 1 | 2 | 2 | 2 |
| CRUSTACEA | | | | | |
| COPEPODA | | | | | |
| Cyclopoida | 0 | 2 | 1 | 0 | 0 |
| Harpacticoida | 1 | 6 | 3 | 4 | 2 |
| Calanoida | 1 | 0 | 1 | 0 | 0 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 8 | 0 | 0 | 4 | 0 |
| Chironomini | 16 | 4 | 5 | 12 | 908 |
| Orthocladiinae | 84 | 110 | 108 | 88 | 73 |
| Tanypodinae | 0 | 4 | 16 | 12 | 21 |
| Tanytarsini | 1191 | 1163 | 920 | 782 | 8 |
| Empididae | | | | | |
| Chelifera | 1 | 2 | 0 | 0 | 0 |
| Hemerodromia | 17 | 9 | 13 | 10 | 16 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 2 | 3 | 1 | 8 | 10 |
| Ephemerellidae | | | | | |
| Ephemerella | 0 | 0 | 1 | 3 | 2 |
| Heptageniidae | 70 | 76 | 47 | 45 | 64 |
| Heptagenia | 0 | 0 | 7 | 2 | 5 |
| Rhithrogena | 14 | 13 | 9 | 23 | 7 |
| Leptophlebiidae | | | | | |
| Paraleptophlebia | 1 | 0 | 0 | 0 | 0 |
| HEMIPTERA | | | | | |
| Corixidae | 0 | 0 | 1 | 0 | 0 |
| PLECOPTERA | | | | | |
| Capniidae | 7 | 1 | 2 | 3 | 2 |
| Perlodidae | 70 | 100 | 80 | 102 | 42 |
| Isoperla | 18 | 32 | 40 | 59 | 77 |

| | | | | | |
|---|---|---|---|---|---|
| Taeniopterygidae | 11 | 0 | 0 | 0 | 0 |
| Oemopteryx | 31 | 80 | 65 | 112 | 85 |
| Plecoptera immature | 2 | 1 | 0 | 2 | 3 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 0 | 1 | 0 | 0 |
| Hydropsychidae | 0 | 2 | 0 | 5 | 0 |
| Cheumatopsyche | 0 | 1 | 0 | 0 | 0 |
| Hydropsyche | 0 | 0 | 0 | 2 | 0 |
| COELENTERATA | 33 | 36 | 34 | 35 | 32 |
| NEMATODA | 25 | 26 | 30 | 21 | 26 |

PEACE RIVER - (B1L) 3 KM U/S DAISHOWA PULPMILL 00AL07HA2150

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY: A.M. ANDERSON AND W.J. ANDERSON
SORTING BY: M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS: W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 4 | 10 | 0 | 5 | 6 |
| Naididae | 25 | 1 | 0 | 9 | 9 |
| Tubificidae | 3 | 8 | 0 | 5 | 1 |
| ARTHROPODA | | | | | |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 1 | 4 | 4 | 2 | 5 |
| COPEPODA | | | | | |
| Cyclopoida | 0 | 0 | 1 | 1 | 1 |
| Calanoida | 7 | 4 | 13 | 9 | 4 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomini | 13 | 11 | 3 | 4 | 6 |
| Orthocladiinae | 1 | 2 | 0 | 12 | |
| Tanypodinae | 1 | 0 | 0 | 2 | 1 |
| Tanytarsini | 0 | 1 | 1 | 0 | 1 |
| Prodiamesinae | 0 | 1 | 1 | 1 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | | | | | |
| Baetis | 0 | 1 | 0 | 0 | 0 |
| Ephemerellidae | | | | | |
| Ephemerella | 0 | 0 | 1 | 0 | 0 |
| Heptageniidae | 0 | 0 | 0 | 1 | 0 |
| PLECOPTERA | | | | | |
| Perlodidae | | | | | |
| Isogenoides | 0 | 1 | 0 | 0 | 0 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 0 | 0 | 0 | 1 |
| Trichoptera immatures | 0 | 0 | 0 | 0 | 2 |
| NEMATODA | 4 | 2 | 4 | 4 | 7 |

PEACE RIVER - (B1R) 4 KM U/S DAISHOWA PULPMILL 00AL07HA2100

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 0 | 0 | 1 | 0 | 0 |
| Naididae | 1 | 10 | 1 | 3 | 8 |
| Tubificidae | 77 | 110 | 46 | 58 | 62 |
| ARTHROPODA | | | | | |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 1 | 0 | 0 | 1 | 0 |
| COPEPODA | | | | | |
| Cyclopoida | 1 | 0 | 2 | 0 | 0 |
| Calanoida | 0 | 0 | 3 | 1 | 1 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Ceratopogonidae | 0 | 0 | 0 | 0 | 1 |
| Chironomidae | | | | | |
| Chironomidae pupae | 1 | 0 | 0 | 0 | 1 |
| Chironomini | 7 | 2 | 9 | 11 | 8 |
| Orthocladiinae | 4 | 3 | 1 | 1 | 2 |
| Tanypodinae | 0 | 1 | 0 | 0 | 0 |
| Tanytarsini | 0 | 1 | 3 | 4 | 4 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 0 | 0 | 4 | 0 |
| Caenidae | | | | | |
| Caenis | 0 | 0 | 0 | 1 | 0 |
| Tricorythidae | | | | | |
| Tricorythodes | 0 | 0 | 0 | 0 | 1 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | 1 | 0 | 0 | 0 | 0 |
| TERRESTRIAL INSECTS | 0 | 0 | 0 | 1 | 0 |
| COELENTERATA | 13 | 13 | 12 | 12 | 16 |
| NEMATODA | 27 | 20 | 10 | 12 | 14 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 1 | 1 | 2 | 3 | 2 |
| Naididae | 5 | 3 | 5 | 4 | 3 |
| Tubificidae | 12 | 6 | 5 | 22 | 21 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 0 | 1 | 1 | 2 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 4 | 1 | 1 | 7 | 1 |
| COPEPODA | | | | | |
| Cyclopoida | 3 | 5 | 2 | 7 | 1 |
| Calanoida | 0 | 0 | 3 | 3 | 4 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Ceratopogonidae | 0 | 0 | 0 | 2 | 0 |
| Chironomidae | | | | | |
| Chironomidae pupae | 1 | 3 | 3 | 3 | 2 |
| Chironomini | 7 | 4 | 24 | 34 | 8 |
| Orthocladiinae | 11 | 4 | 8 | 10 | 2 |
| Tanypodinae | 2 | 2 | 5 | 2 | 2 |
| Tanytarsini | 35 | 47 | 63 | 41 | 25 |
| Empididae | | | | | |
| Hemerodromia | 0 | 0 | 1 | 1 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 0 | 3 | 1 | 0 |
| Ephemerellidae | | | | | |
| Ephemerella | 0 | 1 | 2 | 1 | 0 |
| Heptageniidae | 9 | 6 | 11 | 12 | 3 |
| Heptagenia | 2 | 0 | 14 | 8 | 2 |
| Siphlonuridae | | | | | |
| Ameletus | 3 | 1 | 1 | 1 | 0 |
| PLECOPTERA | | | | | |
| Capniidae | 0 | 1 | 0 | 3 | 1 |
| Chloroperlidae | 1 | 0 | 0 | 1 | 0 |
| Perlidae | | | | | |
| Claassenia sabulosa | 1 | 0 | 0 | 0 | 0 |
| Perlodidae | 6 | 0 | 15 | 13 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| Isogenoides | 0 | 0 | 0 | 1 | 2 |
| Isoperla | 0 | 0 | 1 | 0 | 0 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | 15 | 5 | 5 | 11 | 4 |
| Hydropsyche | 13 | 5 | 14 | 14 | 6 |
| Trichoptera immatures | 0 | 0 | 0 | 1 | 0 |
| COELENTERATA | 68 | 40 | 117 | 123 | 39 |
| NEMATODA | 5 | 4 | 2 | 19 | 9 |

PEACE RIVER - (B2L) 5 KM D/S DAISHOWA SITE 00AL07HA2600

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J.ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | |
|---|---|---|---|
| ANNELIDA | | | |
| OLIGOCHAETA | | | |
| HAPLOTAXIDA | | | |
| Enchytraeidae | 6 | 2 | 47 |
| Naididae | 3 | 12 | 4 |
| Tubificidae | 128 | 34 | 0 |
| ARTHROPODA | | | |
| CRUSTACEA | | | |
| CLADOCERA | | | |
| Daphniidae | | | |
| Daphnia | 3 | 5 | 2 |
| COPEPODA | | | |
| Cyclopoida | 2 | 0 | 1 |
| Calanoida | 10 | 7 | 7 |
| INSECTA | | | |
| DIPTERA | | | |
| Ceratopogonidae | 0 | 0 | 1 |
| Chironomidae | | | |
| Chironomidae pupae | 2 | 0 | 0 |
| Chironomini | 4 | 45 | 7 |
| Orthocladiinae | 0 | 1 | 0 |
| Tanypodinae | 1 | 2 | 0 |
| Tanytarsini | 0 | 0 | 1 |
| Diptera adults | 0 | 0 | 1 |
| EPHEMEROPTERA | | | |
| Ephemerellidae | | | |
| Ephemerella | 0 | 0 | 1 |
| Heptageniidae | | | |
| Heptagenia | 1 | 3 | 4 |
| PLECOPTERA | | | |
| Perlodidae | 1 | 0 | 5 |
| Isogenoides | 0 | 0 | 2 |
| Chloroperlidae | | | |
| Suwallia complex | 1 | 0 | 2 |
| TRICHOPTERA | | | |
| Hydropsychidae | 1 | 2 | 0 |
| Trichoptera immatures | 1 | 0 | 0 |
| COELENTERATA | 152 | 228 | 172 |

| | | | |
|---|---|---|---|
| NEMATODA | 7 | 8 | 9 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 7 | 10 | 12 | 19 | 19 |
| Naididae | 1 | 0 | 0 | 2 | 0 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 0 | 0 | 2 | 0 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 45 | 5 | 48 | 29 | 33 |
| COPEPODA | | | | | |
| Cyclopoida | 9 | 6 | 5 | 11 | 7 |
| Calanoida | 41 | 47 | 46 | 28 | 31 |
| OSTRACODA | 1 | 0 | 0 | 0 | 0 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 6 | 5 | 3 | 3 | 7 |
| Chironomini | 6 | 12 | 9 | 8 | 7 |
| Orthocladiinae | 1 | 5 | 1 | 1 | 1 |
| Tanytarsini | 7 | 10 | 14 | 13 | 21 |
| Tipulidae | 0 | 0 | 1 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 2 | 1 | 0 | 0 | 0 |
| Heptageniidae | 7 | 16 | 5 | 12 | 4 |
| Heptagenia | 0 | 0 | 0 | 1 | 0 |
| Rhithrogena | 2 | 3 | 3 | 1 | 0 |
| Tricorythidae | | | | | |
| Tricorythodes | 0 | 0 | 0 | 0 | 1 |
| PLECOPTERA | | | | | |
| Chloroperlidae | 0 | 1 | 0 | 0 | 1 |
| Perlidae | | | | | |
| Claassenia sabulosa | 0 | 1 | 0 | 0 | 0 |
| Perlodidae | 13 | 22 | 5 | 13 | 6 |
| Isogenoides | 3 | 2 | 1 | 3 | 1 |
| Isoperla | 0 | 1 | 0 | 0 | 0 |
| Taeniopterygidae | 0 | 1 | 1 | 0 | 0 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |

PEACE RIVER - (B2C) 7 KM DOWNSTREAM OF DAISHOWA PULPMILL 00AL07HA2620

| | | | | | |
|---|---|---|---|---|---|
| Brachycentrus | 1 | 1 | 2 | 1 | 1 |
| Hydropsychidae | 0 | 1 | 0 | 2 | 0 |
| Hydropsyche | 2 | 2 | 0 | 0 | 0 |
| TERRESTRIAL INSECTS | 0 | 0 | 1 | 0 | 0 |
| COELENTERATA | 123 | 111 | 88 | 97 | 57 |
| NEMATODA | 2 | 3 | 2 | 2 | 2 |

PEACE RIVER - (B3L) 17 KM D/S DAISHOWA PULPMILL 00AL07HA2640

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 25 | 20 | 82 | 52 | 45 |
| Naididae | 1 | 1 | 2 | 0 | 1 |
| ARTHROPODA | | | | | |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 1 | 3 | 1 | 0 | 3 |
| COPEPODA | | | | | |
| Cyclopoida | 3 | 1 | 0 | 4 | 1 |
| Harpacticoida | 2 | 1 | 30 | 2 | 1 |
| Calanoida | 9 | 3 | 1 | 3 | 0 |
| OSTRACODA | 2 | 0 | 1 | 2 | 0 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 2 | 3 | 2 | 5 | 7 |
| Chironomini | 9 | 6 | 27 | 6 | 4 |
| Orthocladiinae | 0 | 4 | 6 | 3 | 7 |
| Tanypodinae | 1 | 0 | 1 | 0 | 1 |
| Tanytarsini | 14 | 12 | 17 | 13 | 16 |
| Empididae | | | | | |
| Hemerodromia | 1 | 1 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | | | | | |
| Baetis | 0 | 0 | 1 | 0 | 0 |
| Ephemerellidae | 1 | 0 | 0 | 0 | 0 |
| Ephemerella | 0 | 0 | 0 | 0 | 1 |
| Heptageniidae | 0 | 1 | 1 | 1 | 2 |
| Heptagenia | 0 | 0 | 1 | 0 | 0 |
| PLECOPTERA | | | | | |
| Perlodidae | 21 | 21 | 22 | 12 | 9 |
| Isogenoides | 1 | 1 | 1 | 0 | 4 |
| Isoperla | 0 | 0 | 2 | 0 | 0 |
| Plecoptera immature | 0 | 0 | 0 | 1 | 0 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 1 | 0 | 0 | 1 | 0 |
| Hydropsychidae | 4 | 3 | 8 | 2 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Cheumatopsyche | 0 | 0 | 2 | 0 | 0 |
| | Hydropsyche | 9 | 8 | 10 | 6 | 0 |
| COELENTERATA | | 57 | 73 | 158 | 82 | 115 |
| NEMATODA | | 0 | 1 | 2 | 3 | 2 |

PEACE RIVER - (B3R) 20 KM D/S DAISHOWA PULPMILL 00AL07HA2660

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 10 | 5 | 18 | 4 | 15 |
| Naididae | 2 | 1 | 10 | 5 | 1 |
| Tubificidae | 0 | 1 | 4 | 1 | 1 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 0 | 0 | 2 | 2 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 0 | 0 | 1 | 1 | 2 |
| COPEPODA | | | | | |
| Calanoida | 0 | 0 | 3 | 5 | 9 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Ceratopogonidae | 0 | 0 | 1 | 0 | 0 |
| Chironomidae | | | | | |
| Chironomidae pupae | 5 | 0 | 4 | 0 | 3 |
| Chironomini | 2 | 11 | 14 | 3 | 2 |
| Orthocladiinae | 2 | 3 | 11 | 2 | 1 |
| Tanypodinae | 0 | 0 | 1 | 0 | 1 |
| Tanytarsini | 29 | 34 | 28 | 18 | 33 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 1 | 4 | 1 | 2 |
| Baetis | 0 | 3 | 1 | 0 | 2 |
| Heptageniidae | 5 | 16 | 12 | 11 | 9 |
| Cinygmula | 0 | 2 | 0 | 0 | 0 |
| Heptagenia | 0 | 0 | 1 | 1 | 0 |
| Rhithrogena | 11 | 34 | 27 | 15 | 11 |
| PLECOPTERA | | | | | |
| Capniidae | 0 | 0 | 1 | 0 | 0 |
| Chloroperlidae | 1 | 1 | 0 | 0 | 0 |
| Nemouridae | | | | | |
| Malenka | 0 | 0 | 0 | 1 | 0 |
| Perlidae | 0 | 1 | 0 | 1 | 0 |
| Claassenia sabulosa | 0 | 0 | 1 | 0 | 0 |
| Perlodidae | 23 | 41 | 76 | 22 | 20 |
| Isogenoides | 1 | 2 | 6 | 3 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| Isoperla | 0 | 1 | 2 | 1 | 1 |
| Taeniopterygidae | 1 | 0 | 1 | 0 | 0 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 2 | 0 | 0 | 0 |
| Glossosomatidae | | | | | |
| Glossosoma | 0 | 0 | 0 | 1 | 1 |
| Hydropsychidae | 2 | 3 | 19 | 1 | 3 |
| Cheumatopsyche | 0 | 0 | 1 | 0 | 0 |
| Hydropsyche | 13 | 15 | 26 | 4 | 11 |
| Hydroptilidae | | | | | |
| Hydroptila | 0 | 0 | 1 | 0 | 0 |
| COELENTERATA | 32 | 81 | 75 | 59 | 43 |
| NEMATODA | 0 | 1 | 9 | 3 | 5 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 7 | 25 | 3 | 15 | 18 |
| Naididae | 0 | 2 | 0 | 1 | 0 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 0 | 1 | 0 | 1 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 1 | 2 | 3 | 1 | 4 |
| COPEPODA | | | | | |
| Cyclopoida | 1 | 6 | 1 | 2 | 1 |
| Calanoida | 5 | 11 | 9 | 10 | 7 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 1 | 10 | 9 | 14 | 33 |
| Chironomini | 4 | 10 | 6 | 7 | 6 |
| Orthocladiinae | 1 | 8 | 4 | 5 | 2 |
| Tanypodinae | 0 | 1 | 0 | 0 | 0 |
| Tanytarsini | 3 | 6 | 12 | 8 | 16 |
| Simuliidae | 0 | 0 | 0 | 1 | 0 |
| Tipulidae | 1 | 0 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 0 | 3 | 0 | 1 |
| Baetis | 0 | 1 | 0 | 0 | 0 |
| Ephemerellidae | 0 | 0 | 1 | 0 | 1 |
| Ephemerella | 0 | 1 | 0 | 0 | 0 |
| Heptageniidae | 1 | 10 | 7 | 6 | 1 |
| Rhithrogena | 0 | 7 | 7 | 7 | 3 |
| PLECOPTERA | | | | | |
| Perlidae | 0 | 1 | 0 | 0 | 0 |
| Perlodidae | 4 | 23 | 8 | 11 | 15 |
| Isogenoides | 1 | 2 | 3 | 2 | 2 |
| Isoperla | 1 | 3 | 0 | 0 | 1 |
| Taeniopterygidae | 0 | 0 | 0 | 0 | 1 |
| TRICHOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 2 | 1 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Glossosomatidae | | | | | |
| Glossosoma | 0 | 1 | 0 | 0 | 0 |
| Hydropsychidae | 0 | 0 | 1 | 0 | 0 |
| Hydropsyche | 0 | 4 | 2 | 0 | 3 |
| COELENTERATA | 61 | 116 | 65 | 80 | 56 |
| NEMATODA | 0 | 1 | 2 | 7 | 1 |

PEACE RIVER - (B4C) 33 KM D/S DAISHOWA PULPMILL 00AL07HA2700

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 8 | 14 | 27 | 15 | 21 |
| Naididae | 1 | 0 | 0 | 1 | 2 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 1 | 0 | 0 | 0 | 0 |
| CRUSTACEA | | | | | |
| CLADOCERA | | | | | |
| Daphniidae | | | | | |
| Daphnia | 0 | 1 | 2 | 6 | 3 |
| COPEPODA | | | | | |
| Cyclopoida | 0 | 2 | 1 | 0 | 2 |
| Calanoida | 2 | 4 | 0 | 3 | 4 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Chironomidae | | | | | |
| Chironomidae pupae | 4 | 8 | 13 | 7 | 2 |
| Chironomini | 23 | 11 | 15 | 11 | 12 |
| Orthocladiinae | 3 | 4 | 8 | 2 | 7 |
| Tanytarsini | 0 | 2 | 0 | 0 | 3 |
| Tipulidae | 1 | 1 | 2 | 0 | 2 |
| Diptera adults | 1 | 0 | 0 | 0 | 0 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 1 | 2 | 0 | 0 |
| Ephemerellidae | | | | | |
| Ephemerella | 0 | 0 | 0 | 1 | 0 |
| Heptageniidae | 1 | 3 | 1 | 1 | 1 |
| Rhithrogena | 1 | 0 | 1 | 0 | 0 |
| HEMIPTERA | 1 | 0 | 0 | 0 | 1 |
| PLECOPTERA | | | | | |
| Brachycentridae | | | | | |
| Brachycentrus | 0 | 2 | 0 | 0 | 0 |
| Perlodidae | 3 | 2 | 0 | 1 | 2 |
| Isogenoides | 0 | 1 | 2 | 2 | 0 |
| Isoperla | 0 | 0 | 0 | 1 | 1 |
| Taeniopterygidae | 0 | 0 | 1 | 0 | 1 |
| COELENTERATA | 33 | 37 | 38 | 34 | 43 |

| | | | | | |
|---|---|---|---|---|---|
| NEMATODA | 0 | 0 | 1 | 1 | 0 |

SAMPLER: NEILL CYLINDER SAMPLER (0.1 M2)
FINEST MESH SIZE: 0.210 MM
COLLECTIONS BY:A-M ANDERSON AND W.J. ANDERSON
SORTING BY:M. MYCHAJLUK
COUNTS AND IDENTIFICATIONS BY:W.J. ANDERSON

| | REPLICATE | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| Enchytraeidae | 21 | 16 | 11 | 6 | 4 |
| Naididae | 7 | 9 | 16 | 14 | 15 |
| Tubificidae | 58 | 53 | 5 | 6 | 4 |
| ARTHROPODA | | | | | |
| ARACHNOIDA | | | | | |
| ACARI | 3 | 0 | 0 | 0 | 0 |
| CRUSTACEA | | | | | |
| COPEPODA | | | | | |
| Calanoida | 2 | 1 | 1 | 3 | 3 |
| INSECTA | | | | | |
| DIPTERA | | | | | |
| Ceratopogonidae | 0 | 0 | 0 | 0 | 1 |
| Chironomidae | | | | | |
| Chironomidae pupae | 1 | 3 | 1 | 1 | 2 |
| Chironomini | 14 | 27 | 29 | 21 | 7 |
| Orthocladiinae | 3 | 7 | 3 | 0 | 0 |
| Tanypodinae | 2 | 5 | 1 | 1 | 1 |
| Tanytarsini | 2 | 3 | 0 | 2 | 1 |
| Prodiamesinae | 2 | 3 | 0 | 1 | 1 |
| Tipulidae | 0 | 1 | 0 | 0 | 0 |
| Diptera adults | 22 | 6 | 1 | 5 | 4 |
| EPHEMEROPTERA | | | | | |
| Baetidae | 0 | 0 | 0 | 0 | 1 |
| Ephemerellidae | 1 | 0 | 0 | 0 | 0 |
| Ephemerella | 1 | 0 | 0 | 1 | 0 |
| Heptageniidae | 3 | 0 | 0 | 2 | 2 |
| HEMIPTERA | 0 | 4 | 0 | 0 | 1 |
| Saldidae | 2 | 0 | 0 | 0 | 0 |
| PLECOPTERA | | | | | |
| Chloroperlidae | | | | | |
| Suwallia complex | 0 | 0 | 0 | 1 | 0 |
| Perlodidae | 12 | 9 | 0 | 0 | 2 |
| Isogenoides | 2 | 1 | 0 | 0 | 0 |
| TRICHOPTERA | | | | | |
| Hydropsychidae | 17 | 21 | 0 | 3 | 4 |
| Hydropsyche | 0 | 1 | 0 | 0 | 0 |
| TERRESTRIAL INSECTS | 0 | 0 | 0 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| COELENTERATA | 225 | 438 | 94 | 14 | 137 |
| NEMATODA | 6 | 5 | 1 | 4 | 10 |

# APPENDIX 6

Benthic Invertebrate Data
Collected in the Immediate Vicinity of
Peace River Oils #1 Well in May 1989

ENVIRONMENTAL ASSESSMENT DIVISION MAY 24, 1989

PEACE RIVER - 100 mm Upstream of Peace River Oils #1

SAMPLER: Ekman dredge (22.5 x 22.5 $cm^2$)
FINEST MESH SIZE: 0.400 mm
COLLECTIONS BY: B. Jackson and J. Willis
COUNTS AND IDENTIFICATIONS BY: R. Casey

| | | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| NAIDIDAE | 2 | 5 | 0 | 2 | 1 |
| TUBIFICIDAE | 28 | 10 | 23 | 15 | 11 |
| ARTHROPODA | | | | | |
| CRUSTACEA | | | | | |
| COPEPODA | | | | | |
| CYCLOPOIDA | 0 | 0 | 2 | 0 | 0 |
| INSECTA | | | | | |
| COLLEMBOLA | 1 | 4 | 2 | 0 | 0 |
| DIPTERA | | | | | |
| CERATOPOGONIDAE | 0 | 1 | 2 | 4 | 8 |
| CHIRONOMIDAE | | | | | |
| ORTHOCLADIINAE | 6 | 230 | 30 | 158 | 16 |
| TANYPODINAE | 16 | 9 | 2 | 9 | 3 |
| CHIRONOMINAE | 10 | 2 | 0 | 0 | 0 |
| PUPAE | 1 | 2 | 3 | 0 | 2 |
| TIPULIDAE | | | | | |
| LIMONIINAE | 0 | 0 | 1 | 1 | 0 |
| EPHEMEROPTERA | 0 | 0 | 0 | 0 | 1 |
| BAETIDAE | 2 | 2 | 0 | 0 | 0 |
| PLECOPTERA | 1 | 1 | 0 | 0 | 0 |
| PERLODIDAE | 0 | 0 | 0 | 1 | 0 |
| CAPNIIDAE | 0 | 1 | 0 | 0 | 0 |
| TRICHOPTERA | | | | | |
| HYDROPTILIDAE | 0 | 0 | 0 | 1 | 0 |
| ARACHNOIDA | | | | | |
| PSEUDOSCORPIONES | 0 | 1 | 0 | 0 | 0 |
| NEMATODA | 27 | 8 | 32 | 1 | 13 |

ENVIRONMENTAL ASSESSMENT DIVISION MAY 24, 1989

PEACE RIVER - 100 mm Downstream of Peace River Oils #1

SAMPLER: Ekman dredge (22.5 x 22.5 $cm^2$)
FINEST MESH SIZE: 0.400 mm
COLLECTIONS BY: B. Jackson and J. Willis
COUNTS AND IDENTIFICATIONS BY: R. Casey

| | | | | | |
|---|---|---|---|---|---|
| ANNELIDA | | | | | |
| OLIGOCHAETA | | | | | |
| HAPLOTAXIDA | | | | | |
| NAIDIDAE | 1 | 0 | 0 | 0 | 1 |
| TUBIFICIDAE | 19 | 3 | 3 | 3 | 120 |
| ARTHROPODA | | | | | |
| DIPTERA | | | | | |
| CERATOPOGONIDAE | 0 | 3 | 2 | 3 | 1 |
| CHIRONOMIDAE | | | | | |
| ORTHOCLADIINAE | 24 | 4 | 7 | 11 | 18 |
| TANYPODINAE | 0 | 0 | 1 | 0 | 0 |
| PUPAE | 1 | 0 | 0 | 0 | 0 |
| NEMATODA | 0 | 1 | 0 | 0 | 3 |

# APPENDIX 7

## Hydrogen Sulphide Monitoring in the Vicinity of the Peace River Oils #1 Well

Dave: John T. Agrees to help AMA when this comes in. [signature]

ERCB

# Inter-Office Memorandum

FROM: M. Miller, Environment Protection — 5 September 1989

TO: B. Olson, Grande Prairie Area Office

cc: L. Melnychyn, E.P.
E. J. Morin, B&A
J. R. Nichol, D&P
B. Kemper, A.Env. [signature]

---

**ERCB MOBILE AIR MONITORING REPORT**
**PEACE RIVER OILS NO. 1 WELL**
**25 & 26 JULY 1989**

The attached report summarizes the mobile air monitoring conducted at the Peace River Oils No. 1 Well on the 25 and 26 July 1989, by the ERCB's mobile air monitoring vehicle.

The readings are broken down into houly averages where possible and also peak concentrations for each averaging period. The peak concentrations that appear with a > symbol indicate that the response was beyond the scale of the analyser in use at the time.

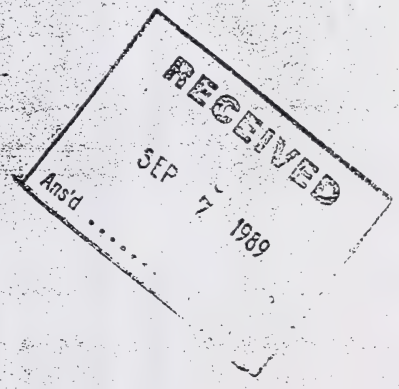
The one-hour average maximum permissible hydrogen sulphide concentration is 0.01 ppm.

If you have any questions regarding this report, please call me at 297-3186.

[signature]

MM/js

Attachments



## ERCB MOBILE AIR MONITORING REPORT

AREA OFFICE: Grande Prairie

AREAS MONITORED: Peace River Oils No. 1 Well

MONITOR OPERATOR: Mark Miller

WEATHER CONDITIONS: $20^0$C, Clear skies, southwest wind at approximately 5 km/h at 10:00 hrs.

DATE: 25 July 1989

| Start/Finish Time | Monitoring Position | Gas Type | Peak Concentration | Average Concentration | Comments |
|---|---|---|---|---|---|
| 10:40 hrs to 11:00 hrs | Northeast of flare approximately 30 m on edge of field. | $H_2S$ | > 0.25 ppm | 0.178 ppm | |
| 11:00 hrs to 12:00 hrs | Northeast of flare approximately 30 m on edge of field. | $H_2S$ | > 0.50 ppm | 0.223 ppm | Change monitoring range on analyser from 0-0.25 ppm to 0-0.5 ppm at 11:00 hrs. |
| 12:00 hrs to 13:00 hrs | North of flare approximately 30 m on edge of field. | $H_2S$ | 0.30 ppm | 0.023 ppm | Wind shift to SSE at 12:00 hrs. Could not get directly in the gas plume as it was over the riverbank. |
| 13:00 hrs to 14:00 hrs | North of flare approximately 30 m on edge of ffeld. | $H_2S$ | 0.32 ppm | 0.056 ppm | |
| 14:00 hrs to 15:00 hrs | North of flare approximately 30 m on edge of field. | $H_2S$ | 0.066 ppm | 0.045 ppm | |
| 15:00 hrs to 16:00 hrs | North of flare approximately 30 m on edge of field. | $H_2S$ | > 0.50 ppm | 0.074 ppm | Wind shifted to north at 15:30 hrs. Monitoring truck positioned approximately 30 m south of flare at 15:30 hrs. |

## ERCB MOBILE AIR MONITORING REPORT

AREA OFFICE: Grande Prairie

MONITOR OPERATOR: Mark Miller

DATE: 26 July 1989

AREAS MONITORED: Peace River Oils No. 1 Well

WEATHER CONDITIONS: $26^{0}$C, Clear skies, west wind at approximately 5 km/h at 09:00 hrs.

| Start/Finish Time | Monitoring Position | Gas Type | Peak Concentration | Average Concentration | Comments |
|---|---|---|---|---|---|
| 09:30 hrs to 10:00 hrs | East of flare approximately 60 m on edge of field. | $H_2S$ | 0.235 ppm | 0.108 ppm | |
| 10:00 hrs to 11:00 hrs | East of flare approximately 60 m on edge of field. | $H_2S$ | 0.385 ppm | 0.109 ppm | |
| 11:00 hrs to 12:00 hrs | East of flare approximately 60 m on edge of field. | $H_2S$ | 0.282 ppm | 0.110 ppm | |
| 12:00 hrs to 12:15 hrs | East of flare approximately 60 m on edge of field. | $H_2S$ | 0.34 ppm | 0.125 ppm | |
| 12:15 hrs to 13:00 hrs | East of well approximately 300 m along east side of farm field. | $H_2S$ | 0.005 ppm | 0.004 ppm | |

# APPENDIX 8

## Results of Groundwater Monitoring

Alberta

MEMORANDUM

ENVIRONMENT WATER RESOURCES MANAGEMENT SERVICES

FROM E. Lorberg, P. Geol.
Hydrogeology Branch
Technical Services Division

OUR FILE REFERENCE 55.3.1.

YOUR FILE REFERENCE

TO D. Trew, Section Head
Water Quality Assessment
Environmental Quality Monitoring Branch

DATE September 28, 1989

TELEPHONE

SUBJECT Peace River Oils No. 1 Well

Following the meeting of September 20, 1989, the attached summary is transmitted for your consideration. In the absence of field data that could be produced through a comprehensive drilling and testing program I feel not entirely assured of the conclusion presented, although alternative options appear less realistic.

E. Lorberg, P. Geol.
Hydrogeology Branch
Technical Services Division

EL/sn

attach.

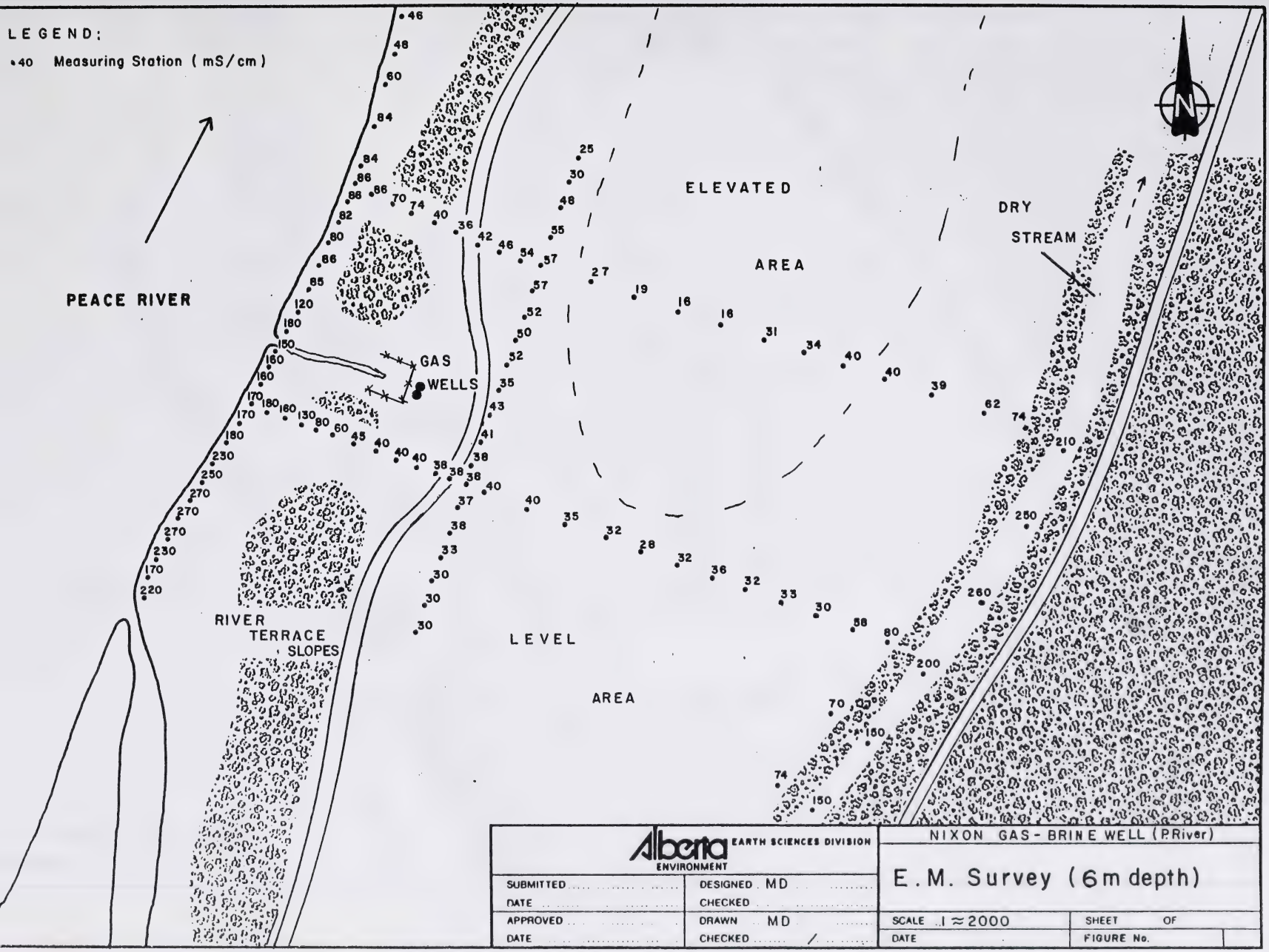
## GROUNDWATER

Alleged saltwater contamination of soil and groundwater and the development of 'sinkholes' was investigated in the vicinity of the Peace River Oils No. 1 Well in July, 1989.

An electro-magnetic (EM) survey was run around the oil well to include a line along the Peace River, and a traverse across a flood-plain and along a flood water channel at the base of the east valley slope where a blow-out cavity was located. This survey also included a line that traversed a collapse feature, thought to be a 'sinkhole'. EM measurements did not decisively reflect elevated ionization in soil and groundwater that would suggest intrusion of saltwater. However, a section of the flood water channel immediately downstream from the blow-out suggests remnant saltwater. Similary, elevated measurements along the river and upstream from the discharge point of the oil well water indicate minor shallow infiltration and flow-through although small springs along the bank contain fresh water only. It is also noted that no EM anomaly exists at the site of subsidence possibly a local structural failure of the subsoil. Early aerial photos indicate the presence of such features along a depositional boundary.

Oil and saltwater seepage has long been observed in the Peace River valley. Natural contamenation is therefore expected in valley soils and groundwater in variable quantities.

Based on the evidence collected the subject well cannot be regarded as cause for the actual or alleged anomalies.



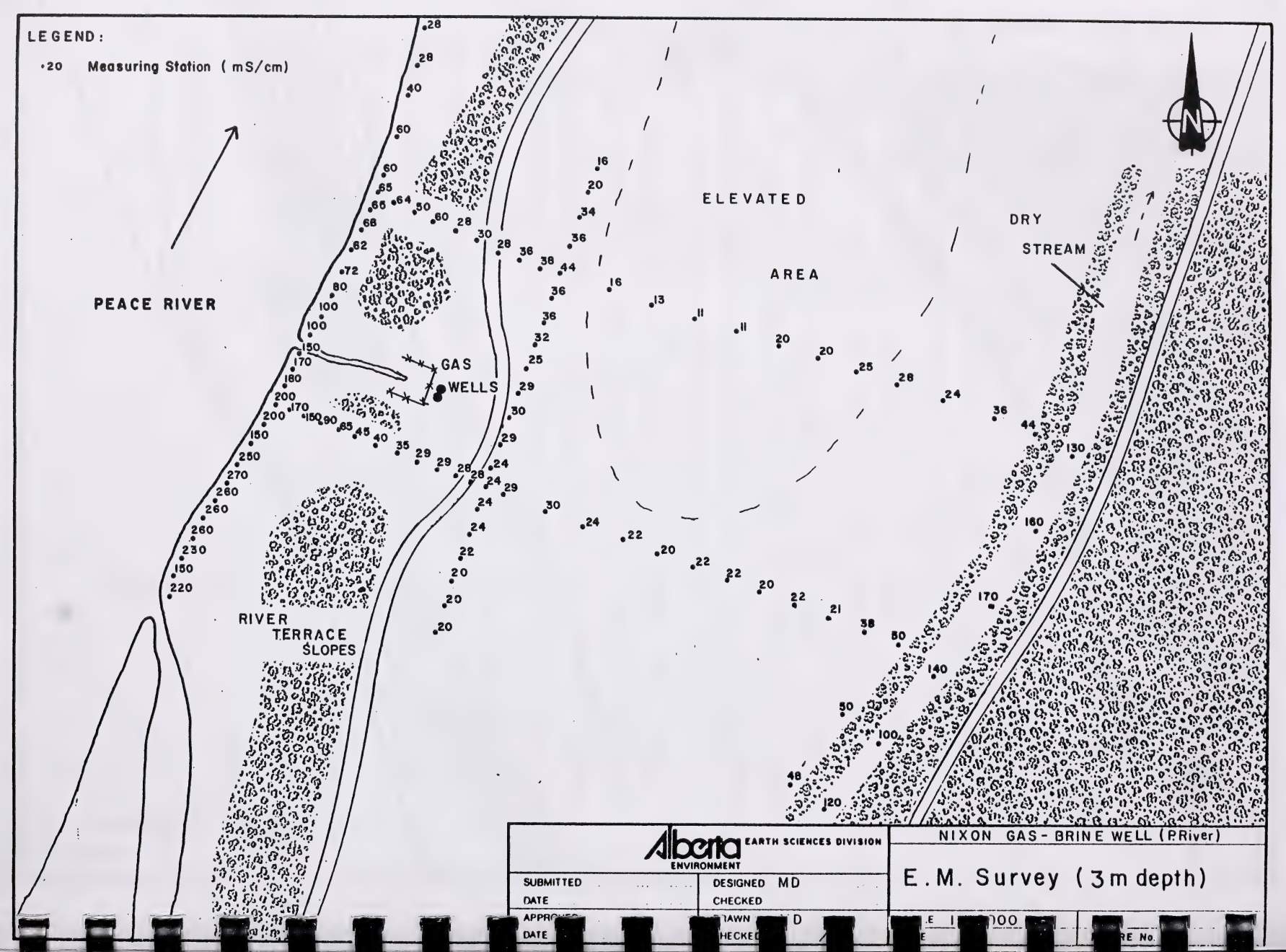

Alberta ENVIRONMENT EARTH SCIENCES DIVISION

| | |
|---|---|
| SUBMITTED ..... | DESIGNED MD ..... |
| DATE ..... | CHECKED ..... |
| APPROVED ..... | DRAWN MD ..... |
| DATE ..... | CHECKED ..... / ..... |

NIXON GAS - BRINE WELL (P.River)

# E. M. Survey (6m depth)

| | |
|---|---|
| SCALE 1 ≈ 2000 | SHEET OF |
| DATE | FIGURE No. |


LEGEND:
·20 Measuring Station ( mS/cm)
PEACE RIVER
GAS
WELLS
ELEVATED
AREA
DRY
STREAM
RIVER
TERRACE
SLOPES
N
Alberta ENVIRONMENT EARTH SCIENCES DIVISION
SUBMITTED
DATE
DESIGNED MD
CHECKED
NIXON GAS - BRINE WELL (P.River)
E.M. Survey ( 3m depth)

# APPENDIX 9

## Routine Water Analysis of Nixon's Old Domestic Well

Alberta

ENVIRONMENT

# MEMORANDUM

WASTES & CHEMICALS DIVISION

FROM Mario deBrentani
Technologist
Groundwater Protection Branch

OUR FILE REFERENCE SW 4-31-85-20-W5

YOUR FILE REFERENCE

TO B. Kemper
Head
Env. Quality Monitoring Branch

Sept. 29/89.

DATE 1989 09 27

TELEPHONE

SUBJECT Flowing Gas Well at Nixon's Property Near Peace River

The domestic water well at the Nixon farm was sampled on July 25, 1989.

The well has a 4 inch diameter steel surface casing and is reported to be about 20 m deep. At the time of sampling, the well was blocked at approximately 2 m from the surface with, what appeared to be, wooden debris. A small diameter plastic hose was forced past the obstructions and a water sample was obtained from approximately 4 m down.

The chemical analysis of this sample reflects the quality of the water in the well but not necessarily that of the geological formation in which the well is completed.

To get a representative sample, the well would have to be cleaned out and pumped for a short period of time to remove the stagnant water.

The water analysis of the sample (attached) was done by Alberta Environmental Centre in Vegreville. The water is the sodium bicarbonate type, often associated with bedrock aquifers. Water well records of the area reveal similar water from wells completed in the river valley both upstream (SW 2-85-21-W5) and downstream (SW 16-86-20-W5) of Nixon's farm. Water from wells to the southeast, outside the river valley, is the calcium magnesium sulphate type, commonly associated with drift aquifers.

The chloride level in the Nixon well is, with 156 mg/L (drinking water limit 250 mg/L), the highest of the 11 wells surveyed. Next highest, with 65 mg/L, is a well 5 km downstream, also in the valley.

This high chloride level together with the presence of phenols, suggest that water from the domestic well at Nixon's farm may be contaminated.

Mario deBrentani

MD/dr

Alberta
ENVIRONMENTAL CENTRE
BAG 4000 VEGREVILLE, ALBERTA T0B 4L0
(403) 632-6761

# WATER ANALYSIS LABORATORY

CERTIFICATION OF ANALYTICAL RESULTS

FRIDAY AUGUST 18th, 1989

SAMPLE
8907901

SOURCE
PEACE RIVER 427-6182
NIXON'S FARM TIME 3 PM

TYPE AND DESCRIPTION
GROUNDWATER

RESULTS TO
DE BRENTANI, MARIO
GROUNDWATER PROTECTION
10405 JASPER AVE
EDMONTON, AB

WELL DEPTH

SAMPLED BY
DE BRENTANI, MARIO

DATE SAMPLED
25/07/89

DATE RECEIVED
01/08/89

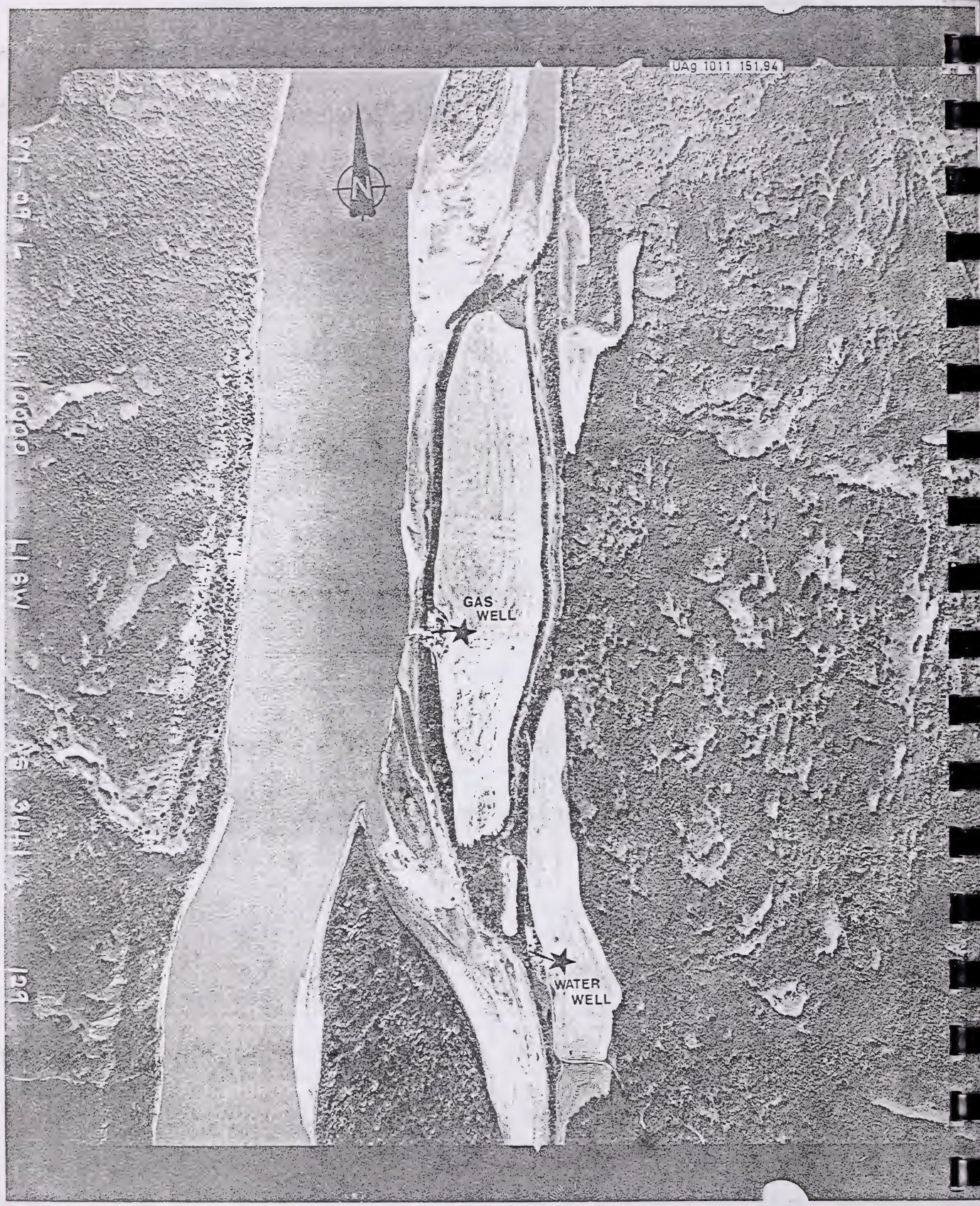
| PARAMETER | NAQUADAT CODE | ANALYTICAL RESULTS | UNITS |
|---|---|---|---|
| PH | 10301L | 7.91 | |
| CONDUCTIVITY | 02041L | 2320. | uS/cm |
| TDS(CALCULATED) | 00205L | 1457. | mg/L |
| CALCIUM | 20107L | 55.0 | mg/L |
| MAGNESIUM | 12105L | 36.0 | mg/L |
| T-HARDNESS | 10602L | 286. | mgCaCO3/L |
| SODIUM | 11103L | 455.0 | mg/L |
| POTASSIUM | 19103L | 4.3 | mg/L |
| (NO2+NO3)-N | 07105L | 0.030 | mg/L |
| NO2-N | 07205L | 0.002 | mg/L |
| FLUORIDE | 09107L | 0.28 | mg/L |
| SULFATE | 16306L | 243. | mg/L |
| CHLORIDE | 17206L | 156.0 | mg/L |
| SILICA | 14107L | 16.5 | mg/L |
| T-ALKALINITY | 10101L | 847. | mgCaCO3/L |
| BICARBONATE | 06201L | 1032. | mg/L |
| CADMIUM | 48009L | 0.003 | mg/L |
| COPPER | 29009L | 0.012 | mg/L |
| NICKEL | 28009L | 0.007 | mg/L |
| COBALT | 27009L | 0.003 | mg/L |
| ZINC | 30009L | 0.111 | mg/L |
| BERYLLIUM | 04103L | <0.001 | mg/L |
| MANGANESE | 25003L | 0.254 | mg/L |
| CHROMIUM | 24009L | 0.005 | mg/L |
| VANADIUM | 23009L | 0.007 | mg/L |
| MOLYBDENUM | 42009L | 0.003 | mg/L |
| BARIUM | 56009L | 0.318 | mg/L |
| IRON (ICP) | 26009L | 7.330 | mg/L |
| LEAD | 82302L | <0.002 | mg/L |

| PARAMETER | NAQUADAT CODE | ANALYTICAL RESULTS | UNITS |
|---|---|---|---|
| COD | 08304L | 42. | mg/L |
| PHENOLS | 06537L | 0.006 | mg/L |
| DOC | 06107L | 8.0 | mg/L |
| DIC | 06154L | 206.0 | mg/L |
| CARBON PART | 06905L | NO VALUE | mg/L |
| NITROGEN PART | 07906L | NO VALUE | mg/L |
| CATIONS | 00120E | 25.60 | |
| ANIONS | 00125E | 26.40 | |
| BALANCE | | 0.97 | |

$NO_2$ = NITRITE $NO_3$ = NITRATE
TDS = TOTAL DISSOLVED SOLIDS

COMMENTS
DEPTH: 10M
INTERIM REPORT (PC&PN TO FOLLOW)

CERTIFIED BY AW
FOR DR. F. P. DIEKEN
HEAD, WATER ANALYSIS & RESEARCH BRANCH
CHEMISTRY DIVISION EXT. 255


UAg 1011 151,94
N
GAS
WELL
WATER
WELL

# APPENDIX 10

## Appraisal of Soil and Crop Condition in the Vicinity of the Peace River Oils #1 Well

Alberta
ENVIRONMENT

# MEMORANDUM

LAND CONSERVATION AND RECLAMATION COUNCIL

FROM: A. Janz
Soils Specialist

OUR FILE REFERENCE:

YOUR FILE REFERENCE:

TO: D. Trew, Head
Environment Quality Monitoring
Branch

DATE: October 6, 1989

TELEPHONE: 427-6212

SUBJECT: Peace River Oils
No. 1 Well 4-31-85-20-W5M
Soils Report

As requested, we submit the final report and map outlining our findings from the site visit on July 25, 1989.

Investigation Date: July 25, 1989
Investigator: Al Malcolm
(Peace River Reclamation Officer)
Arnold Janz (Soils Specialist)

Investigation Methods:

1. Soil profile examination.
2. Apparent conductivity readings (EM-38).
3. General crop appearance.
4. Soil sample collection for lab analysis.

Results:

| Lease Site | Approximate Area | Crop Type | Crop Condition |
|---|---|---|---|
| Area A | 20 m x 40 m | Wheat | Poor |
| Area B | 20 m x 20 m | Barley | Very Poor |
| Area C | 5 m x 5 m | Barley | Bare |
| Area D | 5 m x 15 m | Barley | Excellent |
| Area E | 30 m x 80 m | Weeds | N/A |
| Area F | Control | Wheat /Barely | Poor to Excellent |

.../2

Table One (attached) outlines some physical and chemical soil properties of areas A through F.

Conclusion:

Area A: Crop growth is reduced due to sour smelling gas within the topsoil and subsoil and very poor surface tilth.

Area B: Crop growth is reduced due to sour smelling gas within the topsoil and subsoil, high Cl levels in topsoil and poor soil structure.

Area C: Crop growth is non existent due to factors including
a) high EC
b) high SAR, and
c) high Cl levels

Area D: Crop growth in area D is excellent because of surplus topsoil, good moisture conditions and no chemical restrictions.

Area E: Fenced area.

Area F: Control area with poor to excellent crop growth.

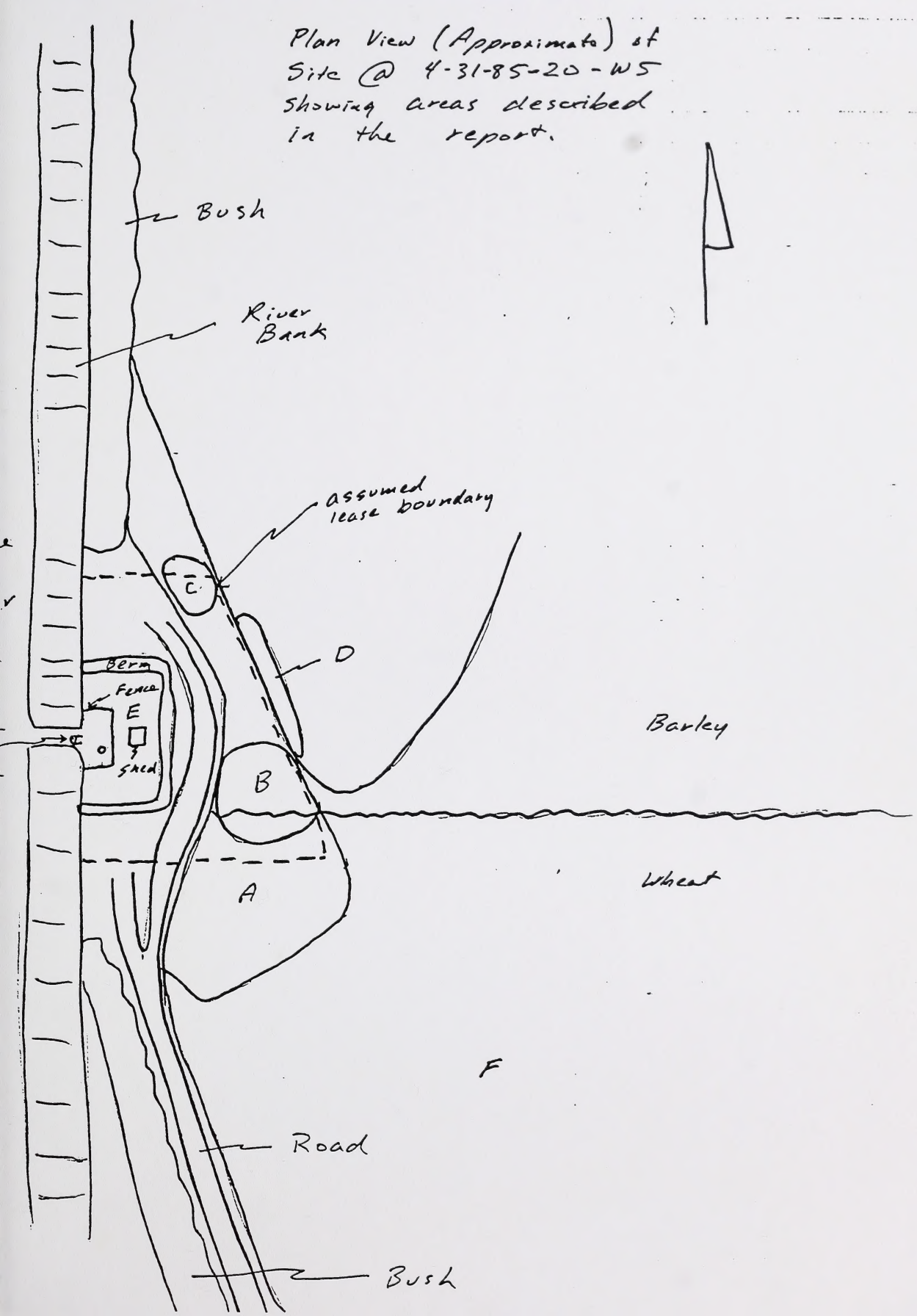
A. Janz

/eh

cc: S. Tracy
J.M. King
A. Malcolm

## TABLE ONE

| Property (0-15 cm) | Area A | Area B | Area C | Area D | Area E | Area F |
|---|---|---|---|---|---|---|
| Cl (meq/l) | 1.14 | 53.0 | 73.1 | - | - | 0.36 |
| pH | 7.2 | 6.9 | 7.4 | - | - | 7.7 |
| E.C. | 1.52 | 3.25 | 14.9 | - | - | 0.88 |
| SAR | 0.2 | 2.6 | 15.5 | - | - | 0.2 |
| Sat % | 50 | 64 | 51 | - | - | 56 |
| Om % | 4.56 | 7.90 | 4.08 | - | - | 6.21 |
| Texture | L | L | L | SL | SL | L |
| Moisture | moist | moist | moist | dry | - | dry |
| Color | red | red | normal | normal | - | normal |
| Gas | present | present | normal | normal | - | normal |
| Topsoil depth (cm) | 10-15 | 10-15 | 15 | 20 | 0 | 15-20 |
| Structure | crusted surface | crusted surface | normal | normal | compact | normal |
| Hydrocarbon % | 0.1 | 0.11 | 0.03 | 0.1 | - | - |


Plan View (Approximate) of Site @ 4-31-85-20-W5 showing areas described in the report.
Bush
River Bank
assumed lease boundary
C
D
Berm
Fence
E
Shed
Barley
B
Wheat
A
F
Road
Bush